

Technical Support Document
For the March 22, 2009
Pagosa Springs Exceptional Event



Prepared by the Technical Services Program
Air Pollution Control Division
Colorado Department of Public Health and
Environment

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1.0 Introduction

PM₁₀ Standards

In July 1987, EPA promulgated National Ambient Air Quality Standards for Particulates with an aerodynamic diameter of 10 microns or less (PM₁₀). This is a size range that can affect the upper airways and can be inhaled into the alveolar regions of the lungs. The standard has one form, a 24-hour standard of 150 µg/m³. The annual arithmetic mean standard of 50 µg/m³ was revoked on October 17, 2006. The 24-hour standard is attained when the expected number of exceedances for each calendar year, averaged over three years, is less than or equal to one. The estimated number of exceedances is computed quarterly using available data and adjusting for missing sample days. A data recovery of 75 percent is needed for each calendar quarter to be considered a valid quarter of data. This standard was modified in by EPA in July 1997, but was subsequently nullified back to this form in May 1999.

Event Overview

On Sunday March 22, 2009, Pagosa Springs, Colorado, recorded an exceedance of the twenty-four-hour PM₁₀ standard with a concentration of 255 µg/m³ at the Pagosa Springs monitor. The Colorado Department of Public Health and Environment (CDPHE) Air Pollution Control Division (APCD) has prepared this report for the U.S. Environmental Protection Agency (EPA) to demonstrate that the elevated PM₁₀ concentrations in Pagosa Springs and other areas of Colorado and the exceedance of the National Ambient Air Quality Standard (NAAQS) for PM₁₀ at Pagosa Springs were caused by a natural event, specifically a dust storm. It will be shown that this exceedance and the high PM₁₀ readings are the consequence of a dust storm in the Four Corners area. This event meets the criteria outlined by the final “Treatment of Data Influenced by Exceptional Events” Rule (72 FR 13560). This report and the analysis and data contained within it show that this exceptional event passed the four required tests (a) through (d) under 40 CFR 50.14 (3)(iv). These tests are:

- (a) The event satisfies the criteria set forth in 40 CFR 50.1(j) which requires that an exceptional event “affects air quality, is not reasonably controllable or preventable...” and that such events are “...natural event[s]”.
- (b) There is a clear causal relationship between the measurement under consideration and the event that is claimed to have affected the air quality in the area.
- (c) The event is associated with a measured concentration in excess of normal historical fluctuations, including background; and
- (d) There would have been no exceedance or violation but for the event.

Elevated 24-hour PM₁₀ concentrations were recorded across much of Colorado on March 22, 2009. Except for the readings in the Denver metropolitan area, all of the March 22 twenty-four-hour PM₁₀ concentrations were above the 90th percentile concentrations for their locations. *The Pagosa Springs concentration exceeds the 99th percentile, and a conservative estimate of the dust storm contribution to the total concentration is 199-211 µg/m³. This is evidence that the event was associated with a measured concentration in excess of normal historical fluctuations including background. But for the dust storm to be described in detail in this report, there would have been no exceedance on this day in Pagosa Springs.*

This exceedance was the consequence of strong southwesterly winds in combination with dry conditions which caused significant blowing dust across much of northeast Arizona, northwest New Mexico, and southwest Colorado. These winds were partly the result of a developing low pressure over the Great Basin and strong winds aloft which mixed down to the surface in the deeply-mixed surface boundary layer. Surface weather analyses show an area of low pressure affecting the Four Corners region. The pressure gradient around the low contributed to strong gusty surface winds across much of Arizona,

northwest New Mexico, and southwest Colorado. *Surface winds of 20 to 50 mph with gusts of 25 to 62 mph were recorded across the Four Corners region on March 22. These speeds are above the thresholds for blowing dust identified in EPA draft guidance and in detailed analyses completed by the State of Colorado.*

EPA's May 2, 2011 draft Guidance on the Preparation of Demonstrations in Support of Requests to Exclude Ambient Air Quality Data Affected by High Winds under the Exceptional Events Rule states "Empirical evidence shows that a sustained wind speed of 25 mph is typically the minimum wind speed needed to entrain particles from many stable surfaces ..." In addition, in both eastern and western Colorado it has been shown that wind speeds of 30 mph or greater and gusts of 40 mph or greater can cause blowing dust (see references for the *Natural Events Action Plan for High Wind Events – Lamar, Colorado* and the *Technical Support Document for the January 19, 2009 Lamar Exceptional Event* and Attachment A - Grand Junction, Colorado, Blowing Dust Climatology at the end of this document). For this blowing dust event, it has been assumed that sustained winds of 25 mph and higher or wind gusts of 40 mph and higher can cause blowing dust in northeast Arizona, northwest New Mexico, and southwest Colorado.

Climatological data for March shows that most of the Four Corners area had received less than 50 percent of the normal precipitation for the month and northeast Arizona was abnormally dry. Hopi in northeastern Arizona received only 0.17 inches of precipitation during the 30 days prior to March 22. This total is well below the approximate threshold for blowing dust conditions at Hopi identified in the analysis contained in Attachment A. Both wind speeds and soil moisture in the Four Corners area and northeastern Arizona were conducive to the generation of significant blowing dust.

Friction velocities calculated for the region also help to explain why blowing dust originated in the Four Corners region and northeastern Arizona in particular. Friction velocities are a function of wind speed, surface roughness, and the change in wind speeds with height above the ground surface. Threshold friction velocities vary with soil type and land cover and are a measure of the minimum conditions necessary for suspension of soil particles in wind. According to Marticorena and coauthors (1997), even undisturbed desert soils normally resistant to wind erosion will be susceptible to blowing dust when friction velocities are greater than about 1.0 to 2.0 meters per second. A wide area of Arizona and New Mexico had friction velocities well above 1.0 meters per second late in the day. Some of the highest values were within the Little Colorado River Valley and Painted Desert region of northeast Arizona. Note that blowing dust will typically only occur where these values are high and the soils are dry and not protected by vegetation, forest cover, boulders, rocks, etc. This is why blowing dust occurred in the desert areas of northeast Arizona and northwest New Mexico on March 22, 2009. *The computed friction velocities, measured wind speeds, and data on soil moisture conditions prove that this dust storm was a natural event that was not reasonably controllable or preventable.*

Satellite imagery shows large plumes of southwest to northeast trending blowing dust in the Painted Desert and Little Colorado River Valley region of northeastern Arizona on March 22. Forward and backward trajectories, wind streamline analyses, and surface and upper-level wind patterns show that this dust would have been transported into Colorado on March 22. An analysis run of a high-resolution meteorological model also shows winds flowing across northeast Arizona and northwest New Mexico into Colorado. This analysis indicates that the zone of highest speeds targeted the Painted Desert and Little Colorado Valley areas of northeastern Arizona – areas shown in Attachment A to be a significant source region for blowing dust transported into Colorado. *Multiple sources of data and analyses of past dust storms in this area prove that this was a natural event and, more specifically, a significant natural dust storm originating in northeastern Arizona and northwestern New Mexico. But for the dust storm on March 22, 2009, this exceedance would not have occurred.*

The Center for Snow and Avalanche Studies (<http://www.snowstudies.org/index.html>) has been studying the effects of desert dust deposition on snowpack albedo and snowmelt in the San Juan Mountains of Colorado. The center's log of events lists March 22, 2009, as one of twelve Dust-on-Snow events for the 2008/2009 water year. Reports and photos from Pitkin County Environmental Health staff and other data indicate that desert dust from the Four Corners region moved as far north as Aspen, Colorado, during the evening of March 22. NOAA's Satellite Service Division also describes blowing dust moving from Arizona into southwest Colorado on March 22, 2009. *Multiple reports from professional experts at other institutions substantiate the conclusion that this was a natural event. But for the dust storm on March 22, 2009, this exceedance would not have occurred.*

2.0 Meteorological Analysis of the March 22, 2009, Blowing Dust Event

On Sunday March 22, 2009, Pagosa Springs Colorado recorded an exceedance of the twenty-four-hour PM₁₀ standard with a concentration of 255 µg/m³ at the Pagosa Springs monitor. Elevated readings were recorded across much of Colorado as shown in Figure 1. *Except for the readings in the Denver metropolitan area, all of these twenty-four-hour PM₁₀ concentrations in Colorado were above the 90th percentile concentrations for their locations. The Pagosa Springs concentration exceeds the 99th percentile, and a conservative estimate of the dust storm contribution to the total concentration is 199-211 µg/m³. This is evidence that the event was associated with a measured concentration in excess of normal historical fluctuations including background.*

This exceedance was the consequence of strong southwesterly winds in combination with dry conditions which caused significant blowing dust across much of northeast Arizona, northwest New Mexico, and southwest Colorado. These winds were partly the result of a developing low pressure over the Great Basin. The surface analysis for 12Z March 22 (5AM MST March 22) presented in Figure 2 shows a broad area of low pressure from Nevada to southeast Montana. This area of low pressure would strengthen and become the 988 millibar low centered over eastern Colorado shown in the 06Z March 23, (11 PM MST March 22) surface analysis in Figure 3. The pressure gradient around the low contributed to the strong gusty surface winds across much of Arizona, northwest New Mexico, and southwest Colorado.

These surface features were associated with a strong upper level trough digging into the western U.S. Figure 4 shows the 500 millibar analysis (at roughly 18,000 feet above sea level) for 12Z March 22, 2009 (5AM MST March 22). The winds on the east side of the trough over much of the southwestern portion of the United States were generally 40 knots with a speed maximum of 90 knots over southern California. Strong winds extended from just above the surface inversion to about 500 millibars. Once the morning inversion had dissipated, the momentum associated with the strong winds above the inversion mixed down to the surface, intensifying the surface winds induced by the surface pressure gradient in Figures 2 and 3. In Figure 5, the 500 millibar analysis for 00Z March 23, 2009 (5 PM MST March 22) shows that the trough had moved east and the speed maximum was over Arizona with a wind speed of 85 knots.

The 00Z March 23, 2009 (5 PM MST March 22) soundings from Flagstaff, Arizona, Albuquerque, New Mexico, and Grand Junction, Colorado, in Figures 6 through 8, respectively, bracket the area that experienced the strong gusty surface winds on March 22, 2009. They show good vertical mixing to near 500 millibars. Wind speeds in the mixed layer (surface boundary layer) ranged from 30 to 60 knots. The combination of the mixing and the tight surface pressure gradient caused surface winds of 20 to 50 mph with gusts of 25 to 62 mph. These winds can be seen in the MesoWest surface analysis of the Four Corners area for 18:31Z March 22, 2009 or 11:31 AM MST, and 23:31Z March 22, 2009 or 4:31 PM MST in Figures 9 and 10 (from <http://www.met.utah.edu/mesowest/>).

EPA's May 2, 2011 draft Guidance on the Preparation of Demonstrations in Support of Requests to Exclude Ambient Air Quality Data Affected by High Winds under the Exceptional Events Rule states "Empirical evidence shows that a sustained wind speed of 25 mph is typically the minimum wind speed needed to entrain particles from many stable surfaces (i.e., undisturbed/natural surfaces with a crust or disturbed surfaces that have been restabilized) in the western U.S. where rainfall is seasonal (see Appendix A), and thus is a useful threshold for setting differential expectations for the detail to be included in a demonstration that dust from a wind event was not reasonably controllable or preventable." In addition, in both eastern and western Colorado it has been shown that wind speeds of 30 mph or greater and gusts of 40 mph or greater can cause blowing dust (see references for the *Natural Events Action Plan for High Wind Events – Lamar, Colorado* and the *Technical Support Document for the January 19, 2009*

Lamar Exceptional Event and Attachment A - Grand Junction, Colorado, Blowing Dust Climatology at the end of this document). For this blowing dust event it is assumed that sustained winds of 25 mph and higher or wind gusts of 40 mph and higher can cause blowing dust in northeast Arizona, northwest New Mexico and southwest Colorado. Figures 2 through 10 show that the conditions necessary for strong gusty winds were in place over the area of concern for the daytime hours of March 22, 2009.

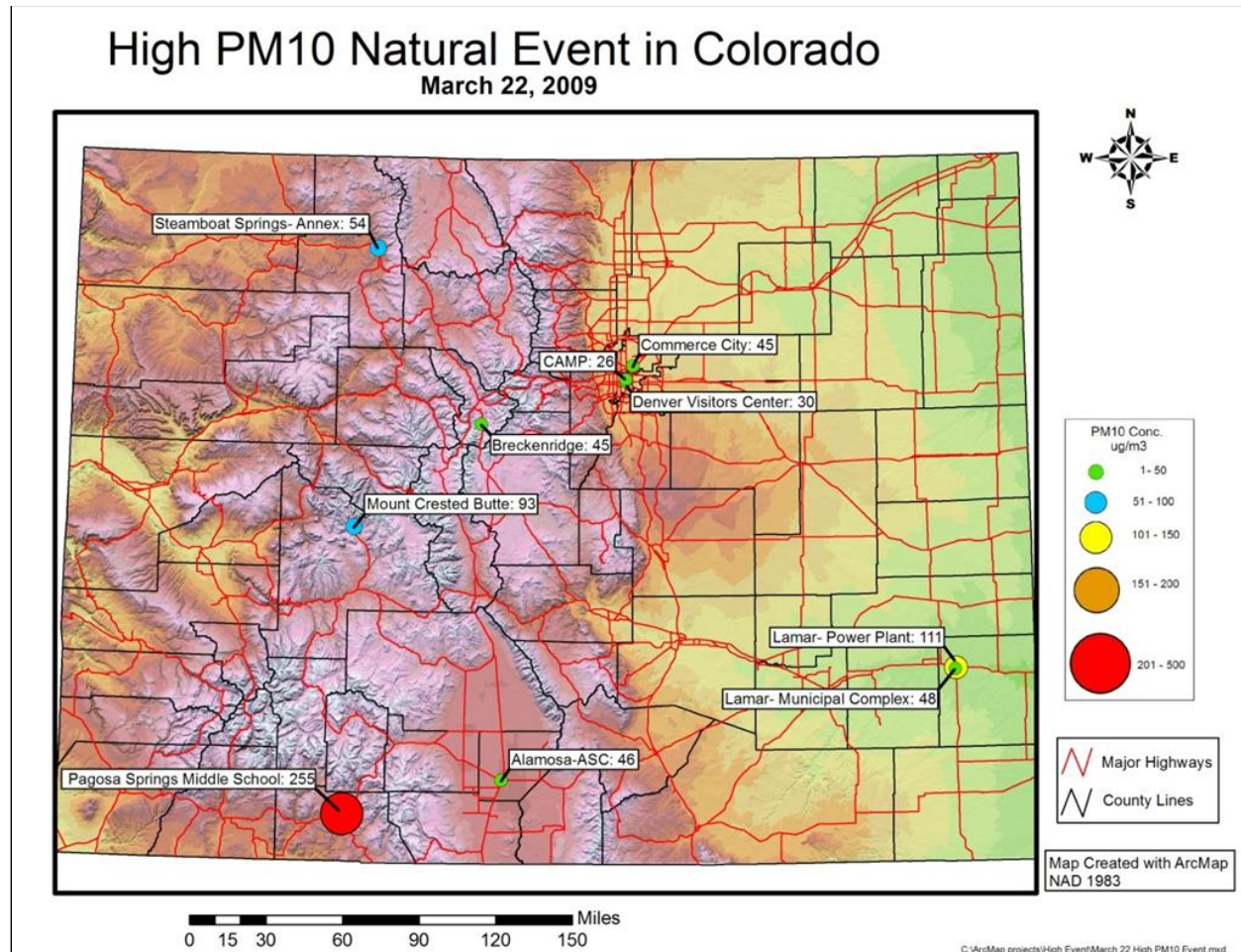


Figure 1. 24-hour PM₁₀ concentrations in $\mu\text{g}/\text{m}^3$ for March 22, 2009.

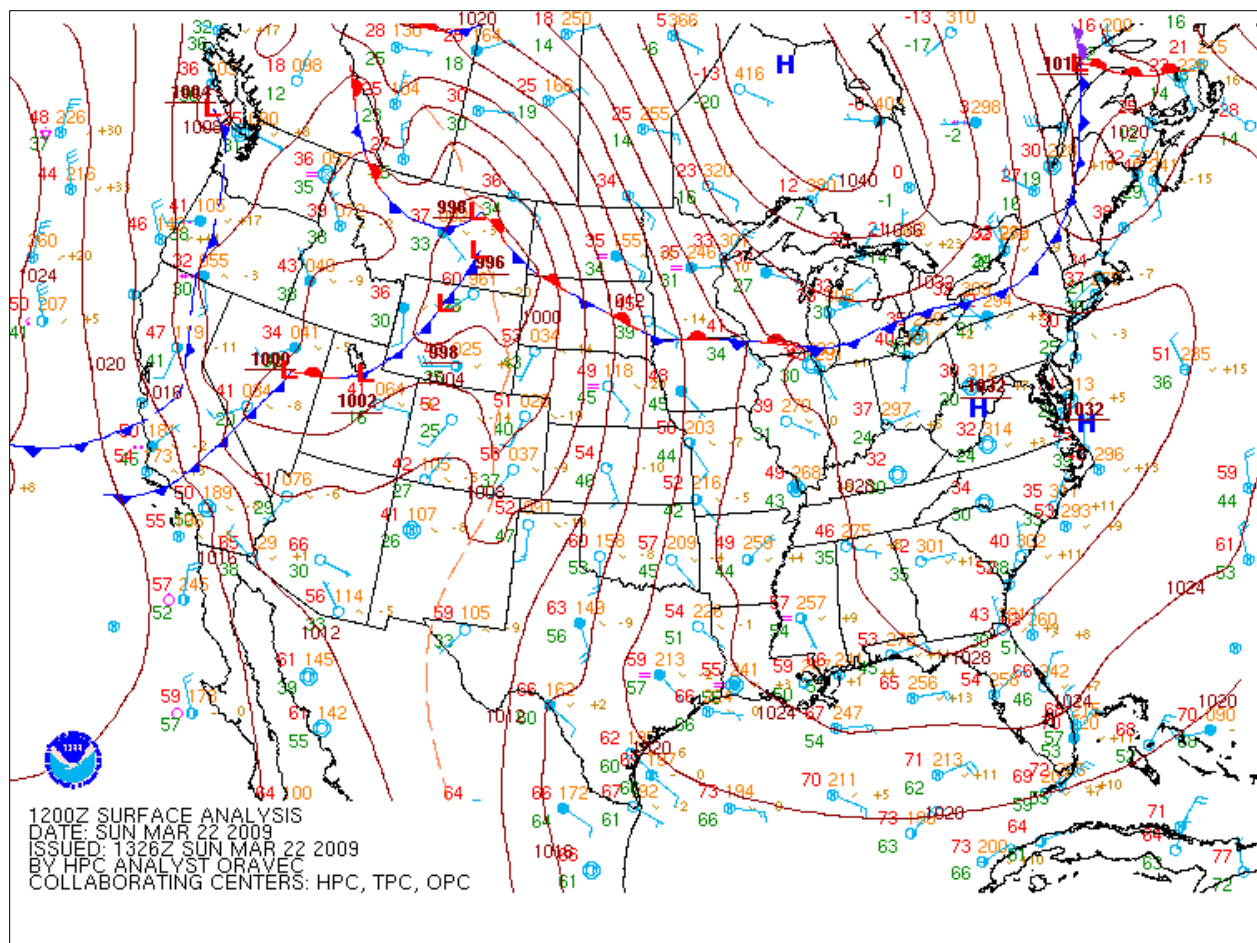


Figure 2. Surface analysis for 12Z March 22, 2009, or 5 AM MST March 22, 2009 (from National Weather Service fax maps <http://nomads.ncdc.noaa.gov/ncep/NCEP>).

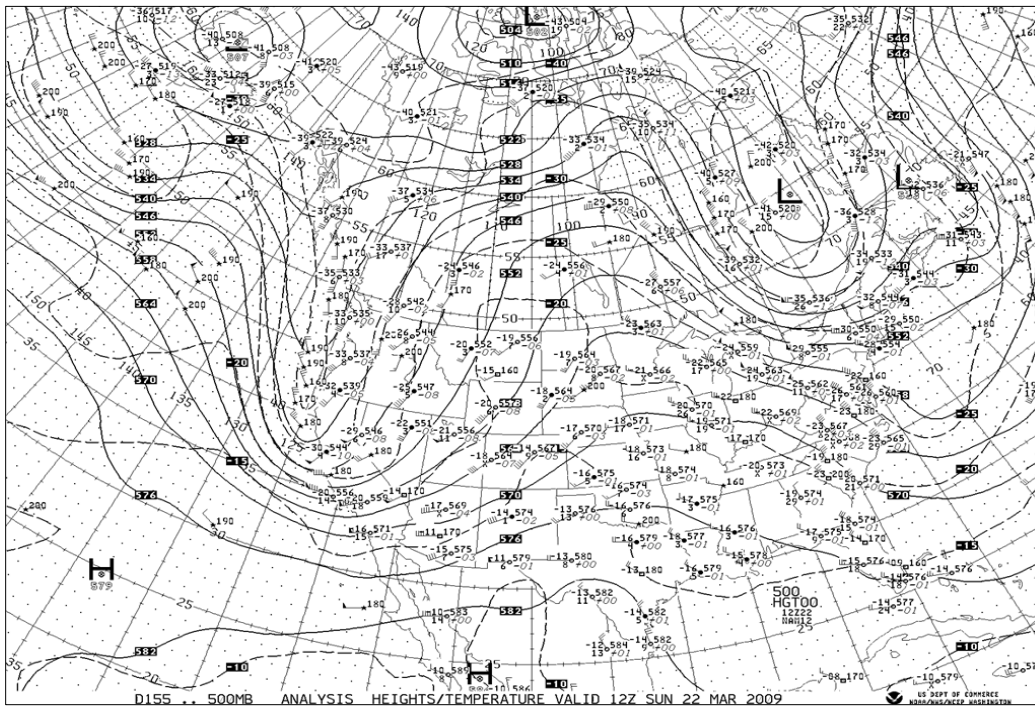


Figure 4. 500 mb analysis for 12Z March 22, 2009, or 5 AM MST March 23, 2009 (from National Weather Service fax maps <http://archive.atmos.colostate.edu/>).

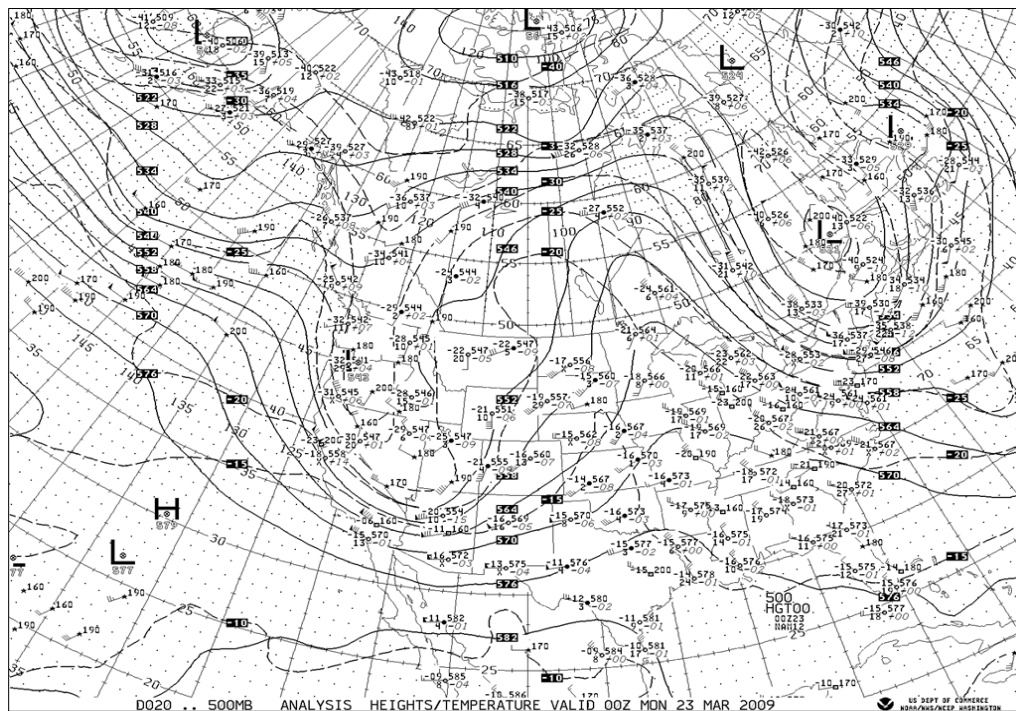


Figure 5. 500 mb analysis for 00Z March 23, 2009, or 5 PM MST March 23, 2009 (from National Weather Service fax maps <http://archive.atmos.colostate.edu/>).

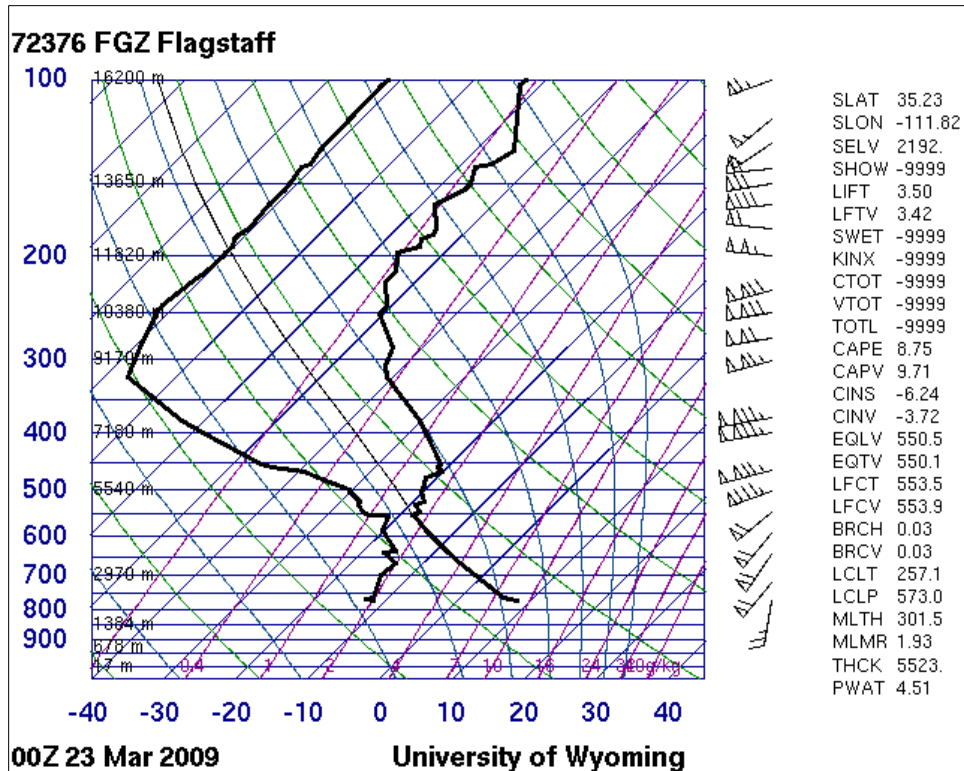


Figure 6. Flagstaff, Arizona sounding analysis for 00Z March 23, 2009 or 5 PM MST March 22, 2009 (<http://weather.uwyo.edu/upperair/sounding.html>).

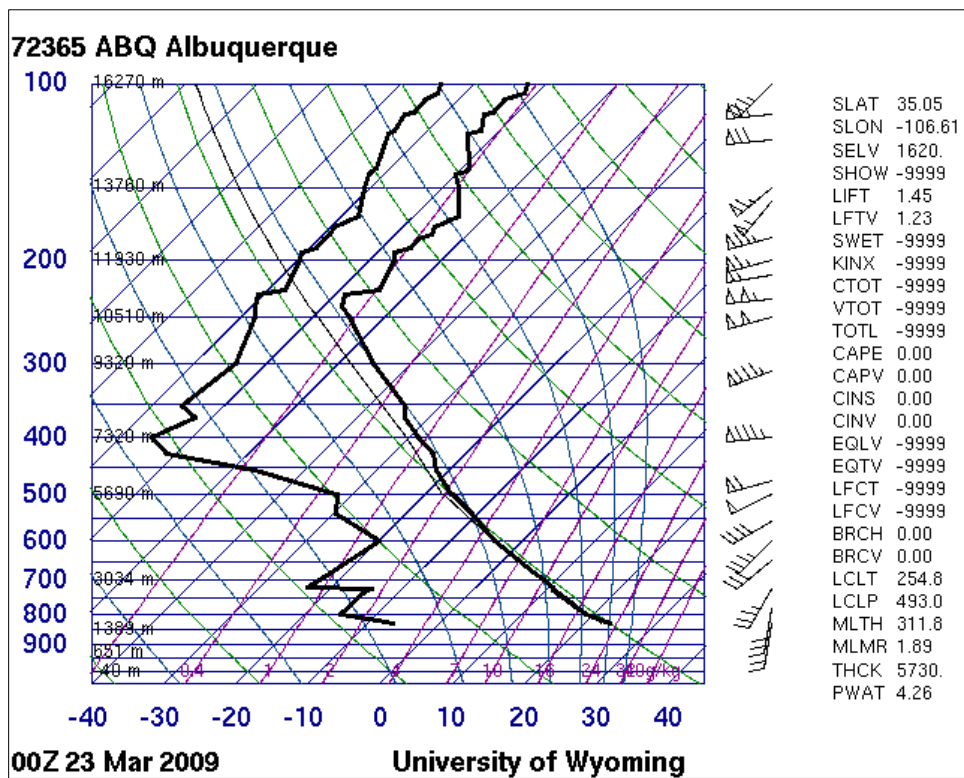


Figure 7. Albuquerque, New Mexico sounding analysis for 00Z March 23, 2009 or 5 PM MST March 22, 2009 (<http://weather.uwyo.edu/upperair/sounding.html>).

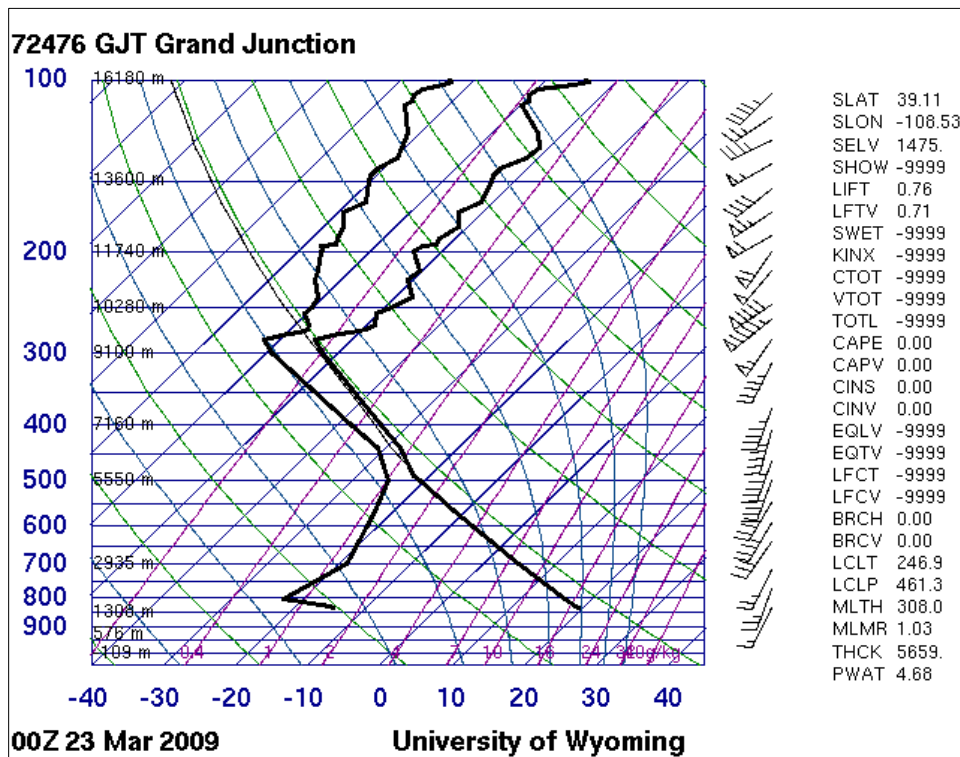


Figure 8. Grand Junction, Colorado sounding analysis for 00Z March 23, 2009 or 5 PM MST March 22, 2009 (<http://weather.uwyo.edu/upperair/sounding.html>).

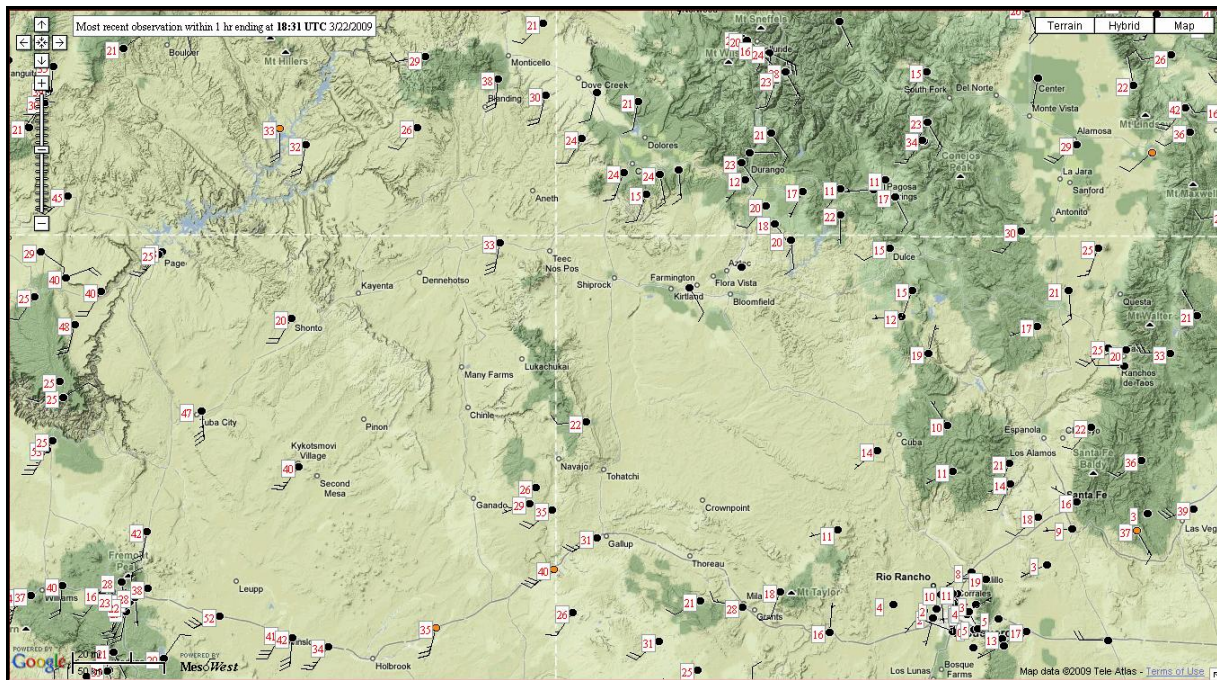


Figure 9. Wind directions and gust speeds in dust source regions and the Pagosa Springs area at 18:31Z March 22, 2009 or 11:31 AM MST on March 22, 2009 (<http://www.met.utah.edu/mesowest/>).

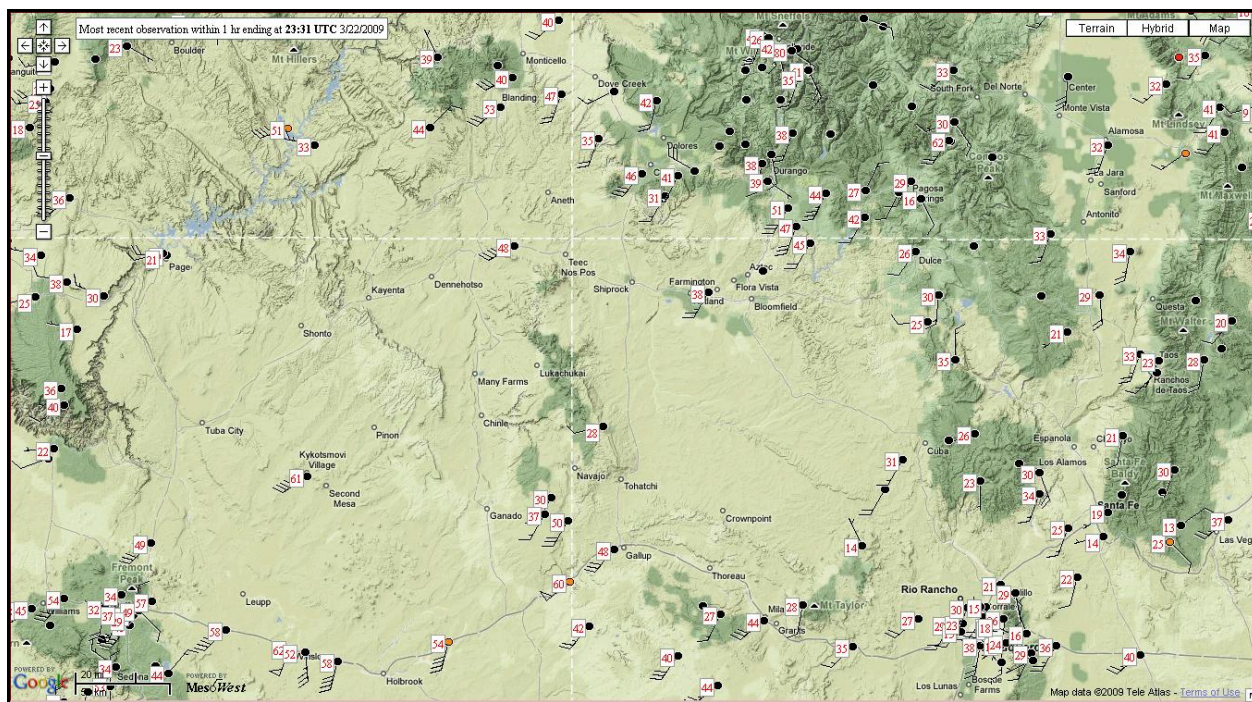


Figure 10. Wind directions and gust speeds in dust source regions and the Pagosa Springs area at 23:31Z March 22, 2009 or 4:31 PM MST on March 22, 2009 (<http://www.met.utah.edu/mesowest/>).

The Service Records Retention System (SRRS) is an archive and access system for selected National Weather Service (NWS) operational products maintained at the National Climatic Data Center (NCDC). Copies of the Southwest Surface Analysis from SRRS for 06Z March 22, 2009 (11 PM MST March 21) to 06Z March 23, 2009 (11 PM MST March 22) are presented in Attachment B. They show the cold front moving across the Southwest U.S. with strong southwest winds ahead of the cold front. The Surface Streamline Analyses for 12Z March 22, 2009 (5 AM MST March 22) through 06Z March 23, 2009 (11 PM MST March 22) are presented in Attachment C. These show southerly to southwesterly surface winds in northeast Arizona and northwest New Mexico flowing into Colorado beginning at 18Z March 22, 2009 (11 AM MST March 22) and continuing until 06Z March 23, 2009 (11 PM MST March 22). Figure 11 shows the surface (10-meter height) streamline analysis for 0Z March 23, 2009 (5PM MST March 22). This plot is based on the analysis-only model run of the NOAA National Center for Environmental Prediction (NCEP) North American Model with 12 kilometer grid spacing (NAM12) based on current observations and high-resolution physics (http://nomads.ncdc.noaa.gov/data.php?name=access#hires_weather_datasets).

The NAM12 analysis also shows the winds flowing across northeast Arizona and Northwest New Mexico into Colorado. The analysis for this time period shows that speeds above blowing dust thresholds and greater than 30 mph were largely confined to the Painted Desert and Little Colorado River Valley areas of northeastern Arizona – areas shown in Attachment A to be a significant source region for blowing dust transported into Colorado.

Figure 12 Shows the Percent of Normal Precipitation for the southwest U.S. during March 2009. Most of the area to the southwest of Pagosa Springs had less than 50 percent of normal precipitation. This lack of precipitation was not limited to March. The region had been abnormally dry since January of 2009 as illustrated in Figure 13. March of 2009 saw below normal soil moisture levels across the region as seen in Figure 14. Figure 15 shows that the dry soils of March represent an intensification of the dryness from

soil moisture levels in February. The Drought Monitor for March 24, 2009 in Figure 16 shows that much of northeast Arizona was classified as having Abnormally Dry conditions. In addition, Hopi, Arizona received only 0.17 inches of precipitation during the 30 days prior to March 22, 2009 (0.17 inches fell on March 12, 2009 (<http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?azAHPI>)). This total is well below the approximate threshold for blowing dust conditions at Hopi identified in Attachment A.

Figure 17 presents the 24-hour back trajectories from the NOAA HYSPLIT model using high-resolution NAM12 meteorological input data (<http://ready.arl.noaa.gov/HYSPLIT.php>) for Pagosa Springs, Colorado, for each hour from 1 AM MST to Midnight MST on March 22, 2009. The back trajectories show that the air over Pagosa Springs came from portions of Arizona and New Mexico on March 22, 2009. The NOAA HYSPLIT Model also has a trajectory matrix option. With this option the model can calculate a grid of forward trajectories over a user-defined region on a map. As will be shown later in this report, northeast Arizona and northwest New Mexico had considerable blowing dust on March 22, 2009. A matrix was created for the NOAA HYSPLIT model that covered this source area and the bounding rectangle for the matrix is presented in Figure 18.

Forward trajectories for this matrix for 8 AM, 11 AM, 2 PM, and 5 PM MST on March 22, 2009 are presented in Figures 19 through 22, respectively. These trajectories start near the time when mixing would begin to bring the momentum of the strong winds above the nighttime inversion to the ground, and also include the periods of the day with the greatest mixing and near the end of the daytime mixing. They show that during these periods the air flowing over the dust source region of northeast Arizona and northwest New Mexico moved into Colorado.

Tables 1 through 10 show the observations for Sandoval Mesa, Colorado (observation near Pagosa Springs); Hayden, Colorado (nearest reporting station to Steamboat Springs); Alamosa, Colorado; Durango, Colorado; Lamar, Colorado; Farmington, New Mexico; Gallup, New Mexico; Kykotsmobi Village, Arizona; Window Rock, Arizona; and Winslow, Arizona respectively. Winds of 25 mph or greater, wind gusts of 40 mph or greater, reduced visibility, and the weather type “haze” are highlighted in yellow in these tables. These locations are near or in the area covered by the HYSPLIT trajectories. Each site except Hayden, the northern most location, had 5 to 11 hours where winds were strong enough to cause blowing dust. Hayden had 2 hours of winds that reached blowing dust thresholds. Durango and Farmington each had 2 hours during which the visibility was reduced due to dust after the wind speeds had dropped below the blowing dust thresholds. This continuation of visibility reductions after such a decline in speeds indicates that dust was transported into the area as implied by the trajectories in Figures 17 and 19 through 22.

Lamar had 5 hours in the early morning with wind speeds or wind gusts at or above blowing dust thresholds (see Table 5). These winds were not directly associated with the storm that caused the blowing dust later in the day on March 22, 2009. They were caused by a low-level jet that is a common occurrence on the Great Plains. This low-level jet is apparent in the 12Z March 22, 2009 (5 AM MST March 22) Dodge City, Kansas, sounding presented in Figure 23. There was a 50-knot wind under the inversion top. This is at the core of the low-level jet. Note that the low-level jet on the Great Plains is more like an elevated sheet of winds that covers a large area than a narrow tube of winds. The reflection of the low-level jet on surface winds can be seen in the 7:47Z March 22, 2009 (or 12:47 AM MST) MesoWest surface analysis for the eastern plains of Colorado, western Kansas, northeast New Mexico, and the panhandles of Texas and Oklahoma in Figure 24. It shows surface winds of 15 to 20 mph and wind gusts to 32 mph across the plains.

Lamar also had 6 hours with wind speeds or wind gusts at or above blowing dust thresholds late in the day on March 22, 2009 (see Table 5). No visibility restrictions were reported, however, and 24-hour concentrations of 48 and 111 $\mu\text{g}/\text{m}^3$ were recorded at the Municipal Building and Power Plant sites,

respectively (note that the Power Plant site is at the facility within the fence-line and does not meet criteria for monitoring ambient air). Both Figures 14 and 15 show that estimated soil moisture levels in southeastern Colorado were near normal during this period. The lower concentrations in Lamar, relative to Durango, lower soil moistures, and moderate concentrations continuing on March 23, 2009 at Lamar (discussed in Section 3.0) are consistent with the transport of dust into southeastern Colorado (which is also supported by the forward trajectories in Figures 21 and 22). Friction velocities calculated for the region also help to explain why blowing dust may have originated in the Four Corners region and not in eastern and southeastern Colorado.

Friction velocities are a function of wind speed, surface roughness, and the change in wind speeds with height above the ground surface. Threshold friction velocities vary with soil type and land cover and are a measure of the minimum conditions necessary for suspension of soil particles in wind. In a 1997 paper “Factors controlling threshold friction velocity in semiarid and arid areas of the United States” (Marticorena et al., 1997), the authors characterized the erodibility of both disturbed and undisturbed desert soil types. The threshold friction velocity, which is described in detail in this paper, is a measure for conditions necessary for blowing dust and is higher for undisturbed soils and lower for disturbed soils.

Friction velocities have been calculated for 6Z, 12Z, and 18Z March 22, 2009, (11 PM MST March 21, 5 AM March 22, and 11 AM March 22, respectively) and 0Z March 23 (5 PM MST March 22) using the North American Regional Reanalysis (NARR) NAM12 model (http://nomads.ncdc.noaa.gov/data.php?name=access#hires_weather_datasets). These friction velocity contour maps are shown in Figures 25 through 28. According to data presented by Marticorena and coauthors (1997), even undisturbed desert soils normally resistant to wind erosion will be susceptible to blowing dust when friction velocities are greater than about 1.0 to 2.0 meters per second. Figure 28 shows that a wide area of Arizona and New Mexico had friction velocities well above 1.0 meters per second late in the day. Some of the highest values were within the Little Colorado River Valley and Painted Desert region of northeast Arizona where satellite imagery shows the eruption of large, dense plumes of blowing dust. Note that blowing dust will typically only occur where these values are high and the soils are dry and not protected by vegetation, forest cover, boulders, rocks, etc. This is why blowing dust occurred in the desert areas of northeast Arizona and northwest New Mexico on March 22, 2009. *The friction velocities shown in Figure 28 and the data on soil moisture conditions presented elsewhere in this report prove that this dust storm was a natural event that was not reasonably controllable or preventable.*

Figures 25 through 28 also help to explain the lack of comparable concentrations of blowing dust in eastern Colorado and the likely transport of Four-Corners area dust into this part of Colorado.

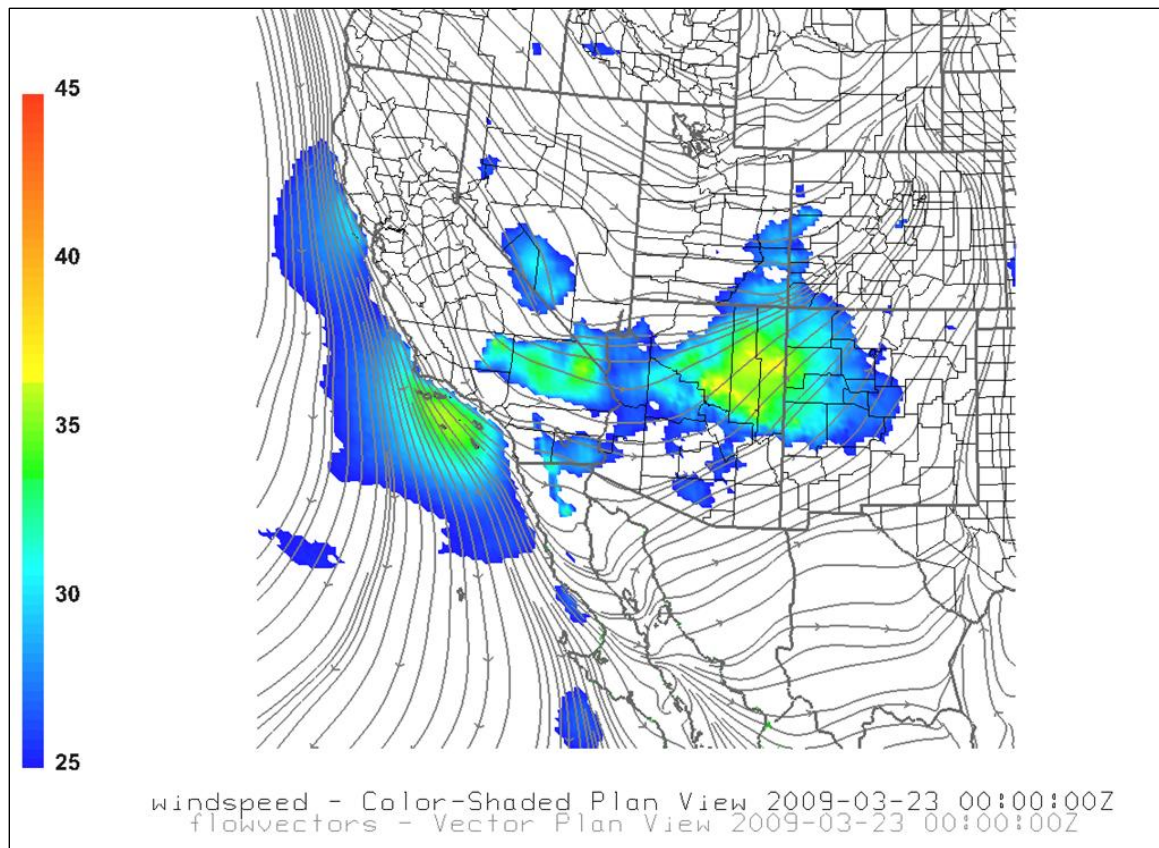


Figure 11. Streamlines from the NOAA NCEP North American Model with 12 kilometer grid spacing at 0Z March 23, 2009 (5 PM MST March 22). Only wind speeds above 25 mph are contoured.

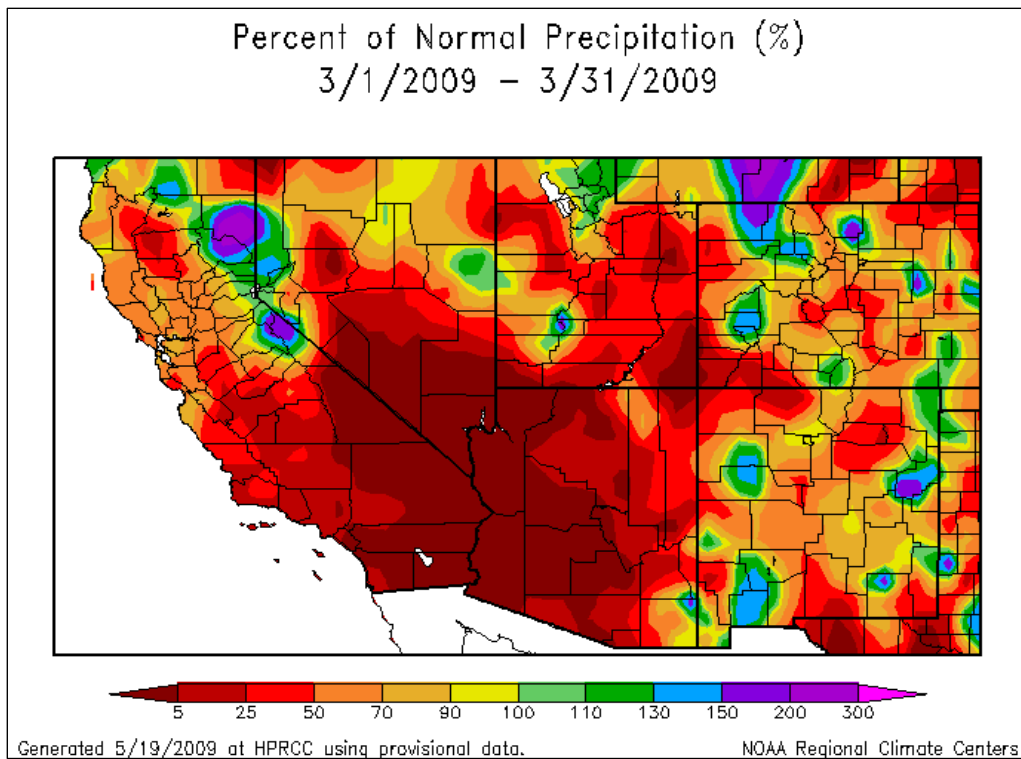


Figure 12. Percent of Normal Precipitation 3/1/2009 – 3/31/2009, source High Plains Regional Climate Center (http://www.hprcc.unl.edu/maps/current/index.php?action=update_product&product=TDdept).

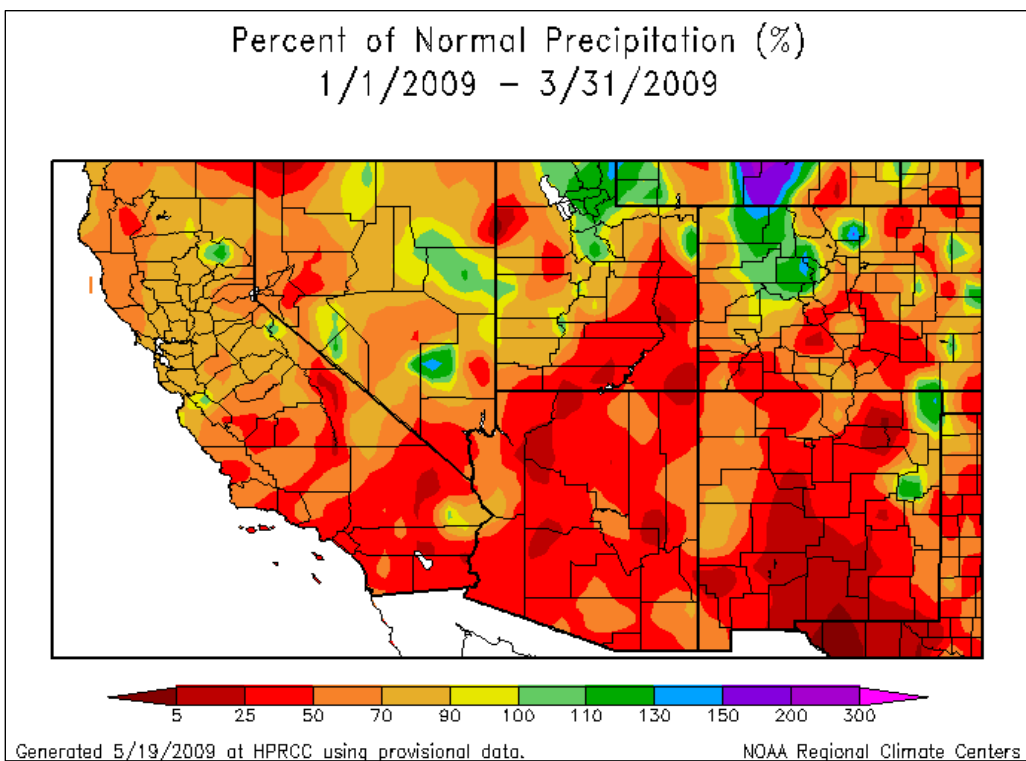


Figure 13. Percent of Normal Precipitation 1/1/2009 – 3/31/2009, source High Plains Regional Climate Center (http://www.hprcc.unl.edu/maps/current/index.php?action=update_product&product=TDdept).

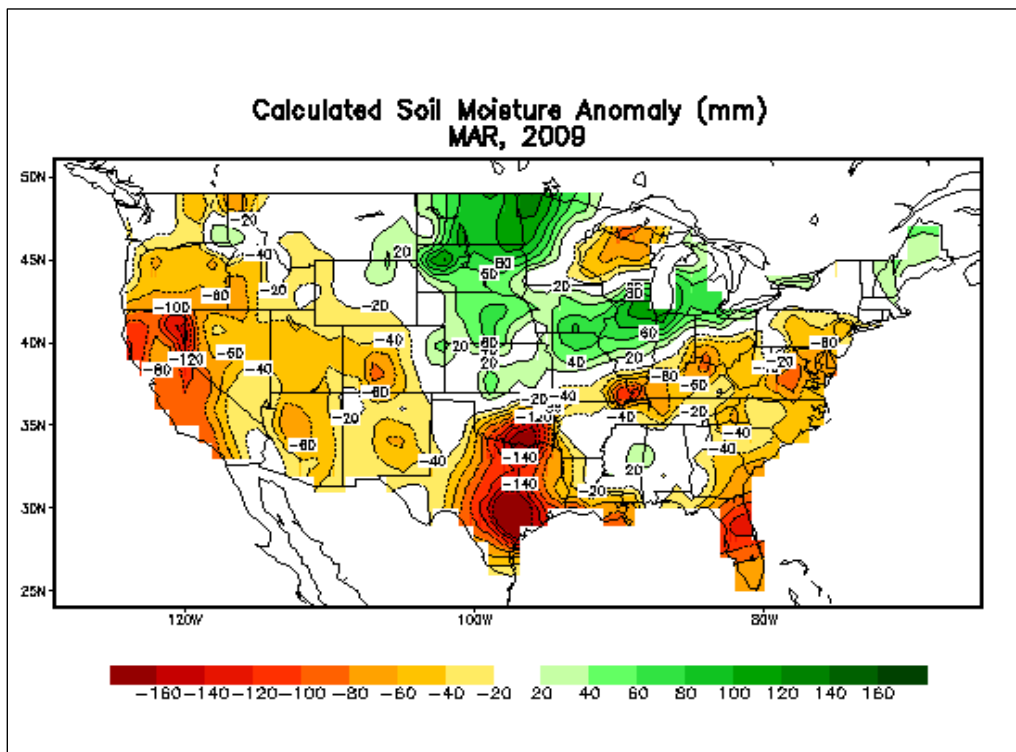


Figure 14. Calculated Soil Moisture Anomaly for March 2009 (http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh).

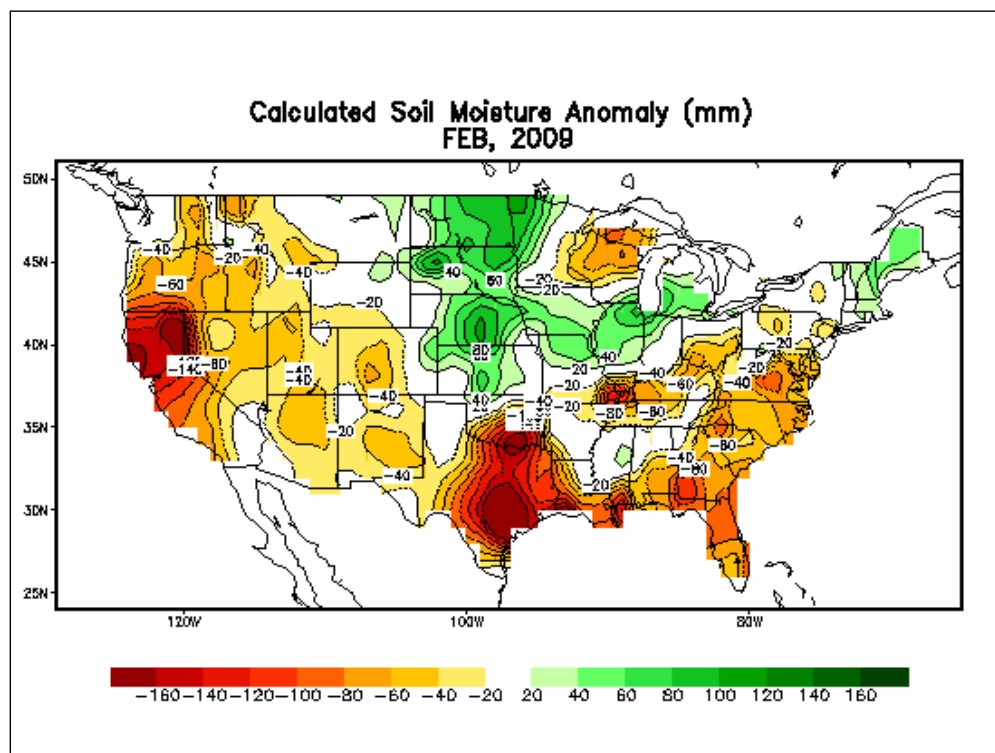


Figure 15. Calculated Soil Moisture Anomaly for February 2009 (http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh).

U.S. Drought Monitor

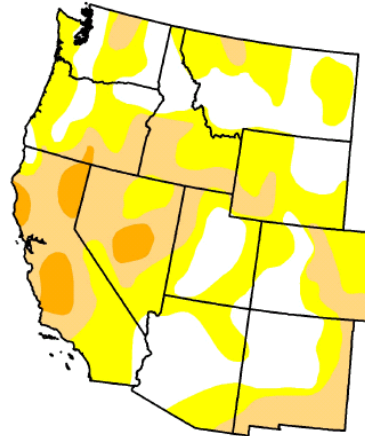
West

March 24, 2009
Valid 7 a.m. EST

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	31.7	68.3	28.5	4.2	0.0	0.0
Last Week (03/17/2009 map)	33.4	66.6	25.8	4.2	0.0	0.0
3 Months Ago (12/30/2008 map)	35.4	64.7	28.9	9.0	0.4	0.0
Start of Calendar Year (01/06/2009 map)	37.4	62.6	28.9	8.8	0.4	0.0
Start of Water Year (10/07/2008 map)	41.3	58.7	28.6	10.4	0.1	0.0
One Year Ago (03/25/2008 map)	41.4	58.6	36.4	15.4	0.0	0.0

Intensity:

D0 Abnormally Dry	D3 Drought - Extreme
D1 Drought - Moderate	D4 Drought - Exceptional
D2 Drought - Severe	



The Drought Monitor focuses on broad-scale conditions.
Local conditions may vary. See accompanying text summary
for forecast statements.



Released Thursday, March 26, 2009

Author: Brad Rippey, U.S. Department of Agriculture

<http://drought.unl.edu/dm>

Figure 16. Drought status for the Colorado on March 24, 2009 (source: the USDA, NOAA, and the National Drought Mitigation Center at: <http://drought.unl.edu/dm/archive.html>).

NOAA HYSPLIT MODEL
Backward trajectories ending at 0600 UTC 23 Mar 09
NAM Meteorological Data

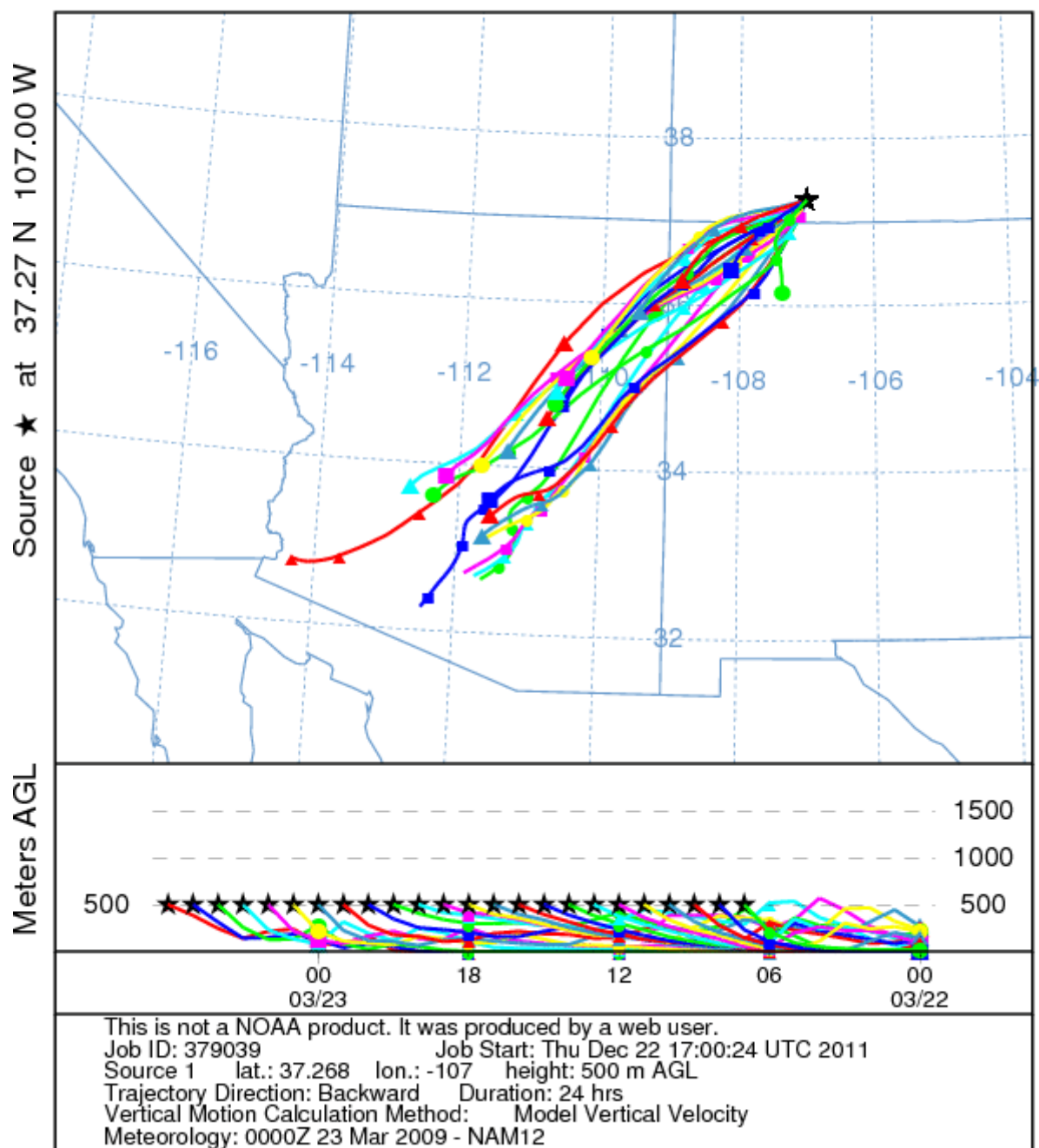


Figure 17. NOAA HYSPLIT 24-hour back trajectories for Pagosa Springs Colorado for each hour from 1 AM MST to Midnight MST on March 22, 2009. The HYSPLIT model run was based on data from the high-resolution 12-kilometer grid spacing NAM numerical weather model (source: NOAA Air Resources Laboratory at: <http://ready.arl.noaa.gov/HYSPLIT.php>).

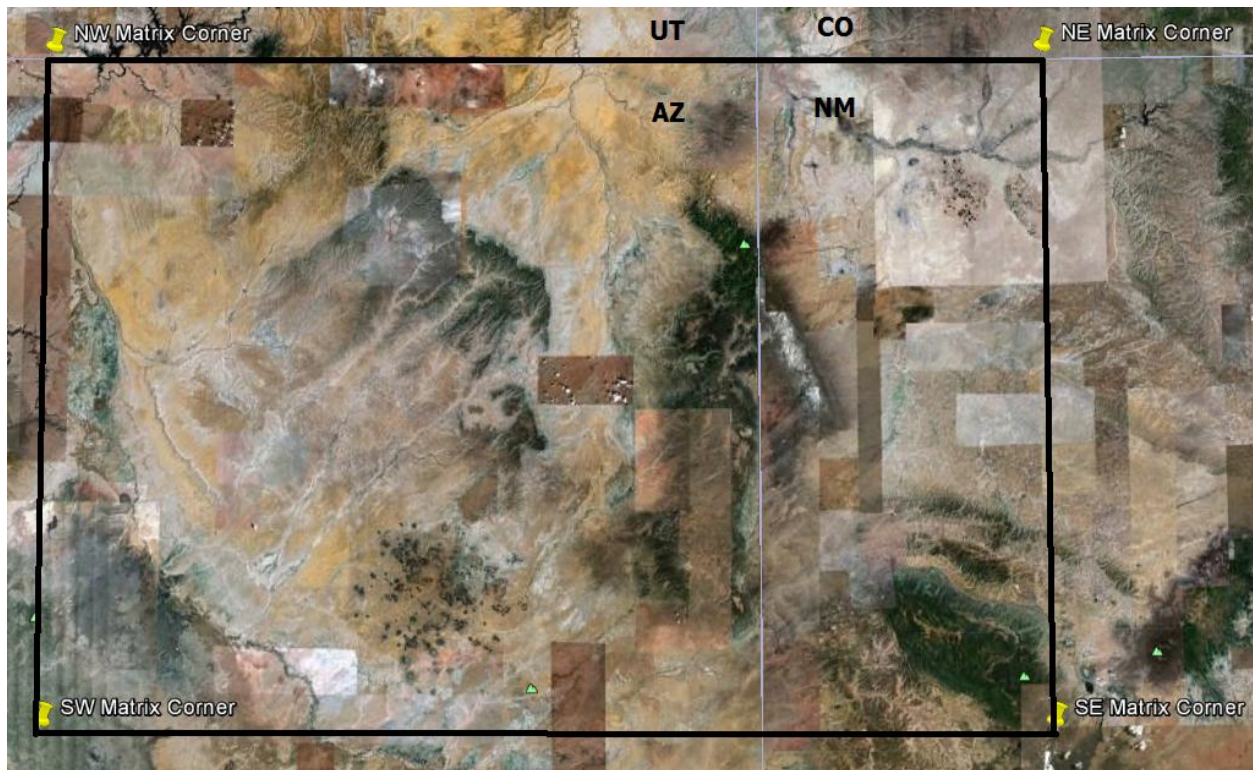


Figure 18. NOAA HYSPLIT MODEL Matrix area for HYSPLIT Matrix forward trajectories in Figures 19–22.

NOAA HYSPLIT MODEL
Forward trajectories starting at 1500 UTC 22 Mar 09
NAM Meteorological Data

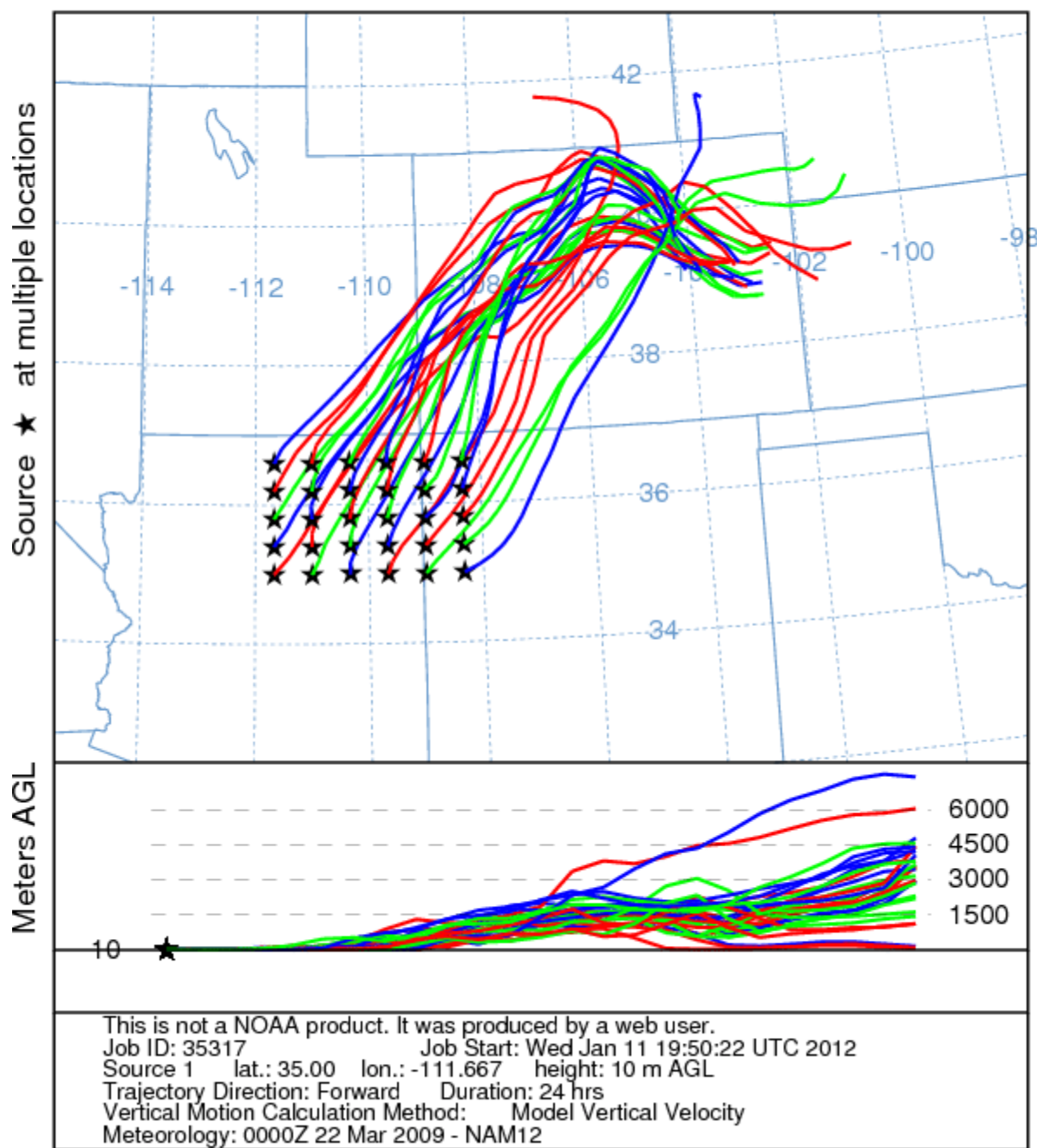


Figure 19. NOAA HYSPLIT 24-hour forward matrix trajectories for 15Z March 22, 2009, or 8 AM MST March 22, 2009. The HYSPLIT model run was based on data from the high-resolution 12-kilometer grid spacing NAM numerical weather model. (source: NOAA Air Resources Laboratory at: <http://ready.arl.noaa.gov/HYSPLIT.php>).

NOAA HYSPLIT MODEL
Forward trajectories starting at 1800 UTC 22 Mar 09
NAM Meteorological Data

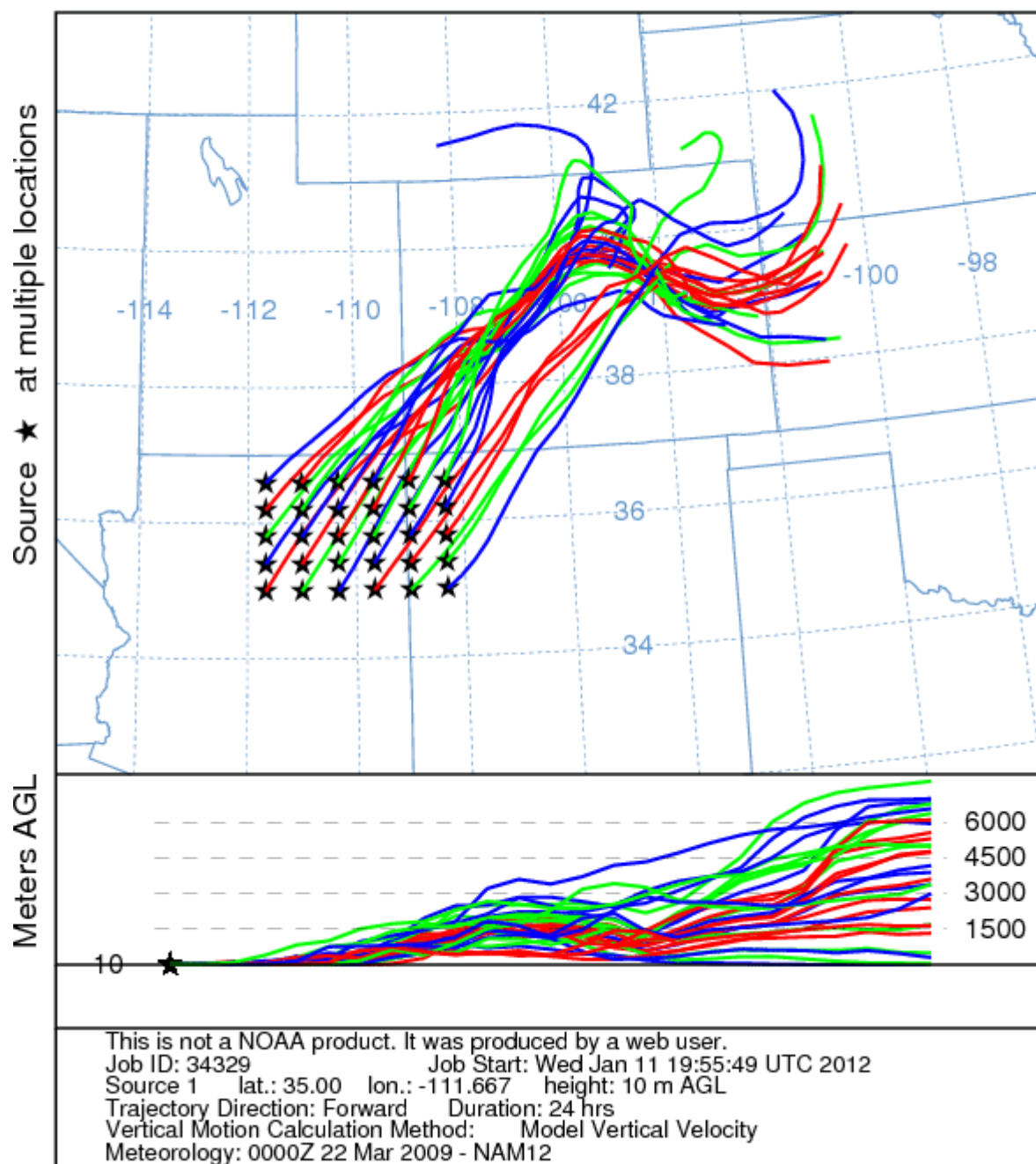


Figure 20. NOAA HYSPLIT 24-hour forward matrix trajectories for 18Z March 22, 2009, or 11 AM MST March 22, 2009. The HYSPLIT model run was based on data from the high-resolution 12-kilometer grid spacing NAM numerical weather model. (source: NOAA Air Resources Laboratory at: <http://ready.arl.noaa.gov/HYSPLIT.php>).

NOAA HYSPLIT MODEL
Forward trajectories starting at 2100 UTC 22 Mar 09
NAM Meteorological Data

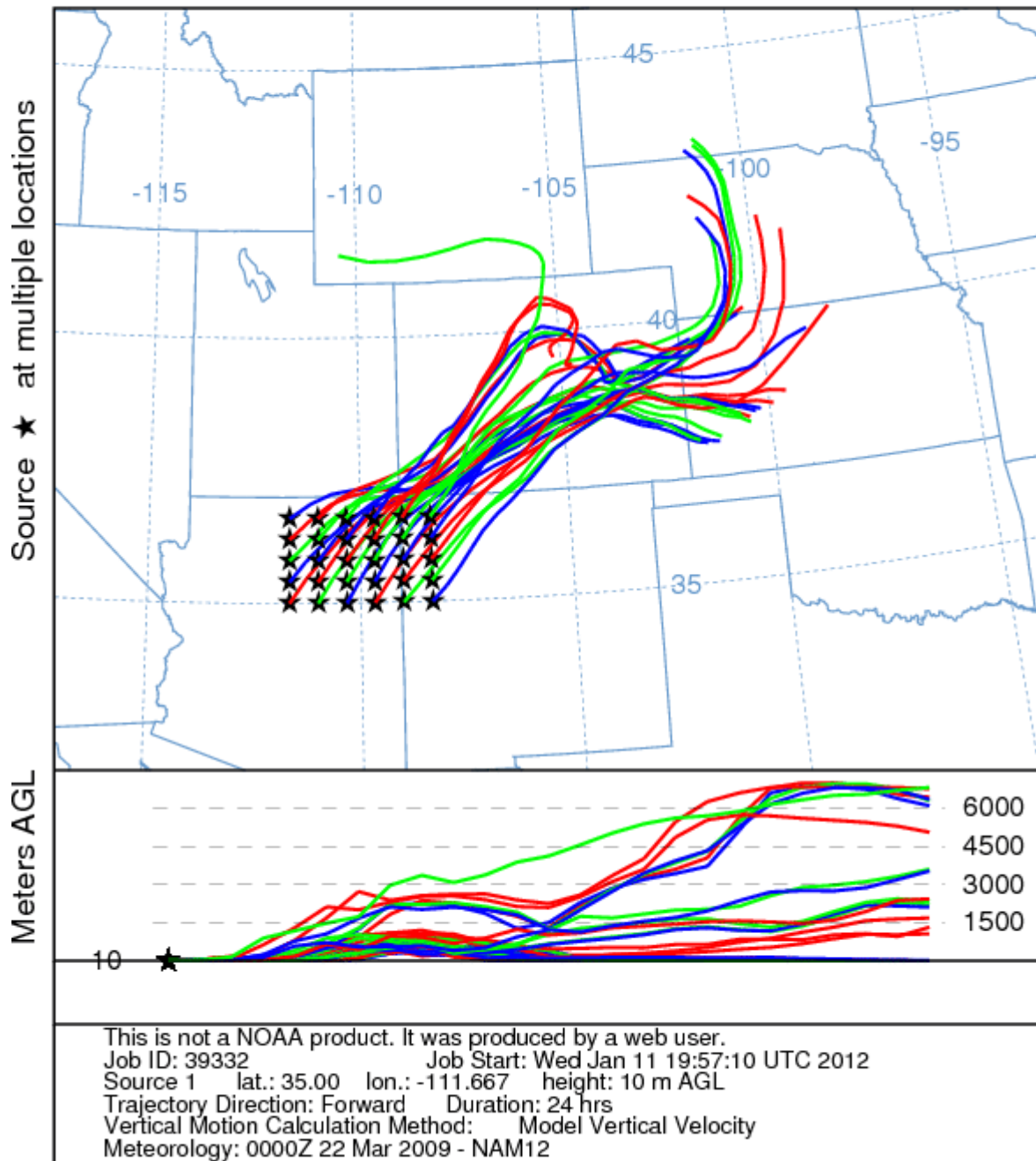


Figure 21. NOAA HYSPLIT 24-hour forward matrix trajectories for 21Z March 22, 2009, or 2 PM MST March 22, 2009. The HYSPLIT model run was based on data from the high-resolution 12-kilometer grid spacing NAM numerical weather model. (source: NOAA Air Resources Laboratory at: <http://ready.arl.noaa.gov/HYSPLIT.php>).

NOAA HYSPLIT MODEL
Forward trajectories starting at 0000 UTC 23 Mar 09
NAM Meteorological Data

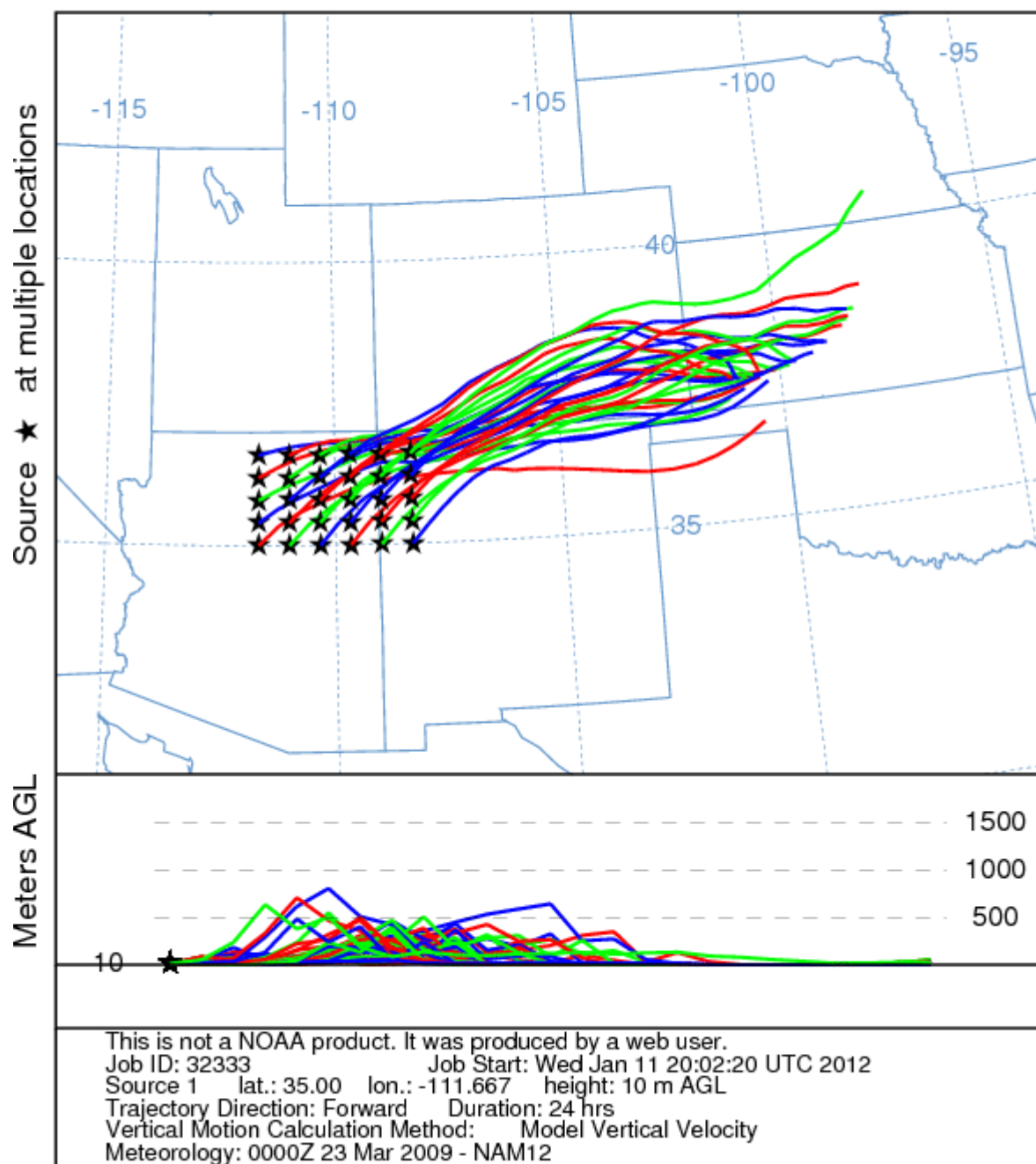


Figure 22. NOAA HYSPLIT 24-hour forward matrix trajectories for 00Z March 23, 2009, or 5 PM MST March 22, 2009. The HYSPLIT model run was based on data from the high-resolution 12-kilometer grid spacing NAM numerical weather model. (source: NOAA Air Resources Laboratory at: <http://ready.arl.noaa.gov/HYSPLIT.php>).

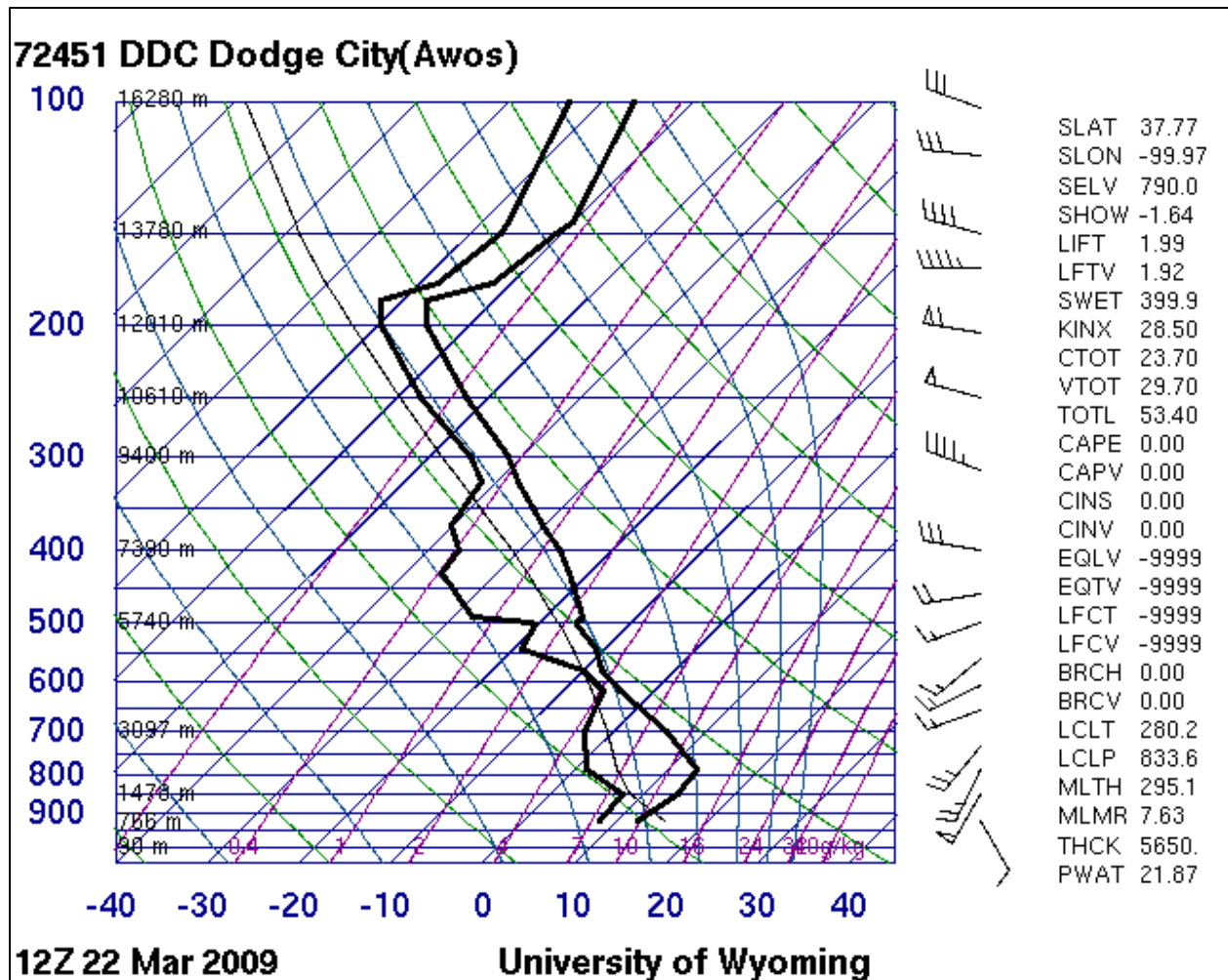


Figure 23. Dodge City sounding analysis for 12Z March 22, 2009, or 5 AM MST March 22, 2009 (<http://weather.uwyo.edu/upperair/sounding.html>).

Table 1. Wind and weather observations for Sandoval Mesa, Colorado, (about 20 miles southwest of Pagosa Springs) reported by the University of Utah MesoWest site for March 22, 2009 (<http://www.met.utah.edu/mesowest/>). Speeds at or above the blowing dust thresholds, weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time in MST March 22	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
23:53	34	54	6	32	235		
22:53	34	50	12	30	299		
21:53	39	30	11	45	268		
20:53	45	15	15	44	243		
19:53	48	14	16	37	226		
18:53	51	14	13	43	223		
17:53	53	14	19	41	219		
16:53	57	14	17	42	211		
15:53	58	15	19	37	203		
14:53	58	16	16	28	205		
13:53	57	20	9	25	192		
12:53	57	20	12	20	189		
11:53	56	27	7	22	184		
10:53	51	34	10	19	189		
9:53	46	44	10	17	181		
8:53	41	45	8	14	181		
7:53	42	43	9	13	182		
6:53	41	40	8	13	185		
5:53	42	38	5	16	211		
4:53	44	37	5	17	226		
3:53	45	34	8	20	211		
2:53	45	32	8	21	232		
1:53	46	30	9	20	207		
0:53	48	28	9	19	211		

Table 2. Wind and weather observations for Hayden, Colorado, (about 224 miles north of Pagosa Springs) reported by the University of Utah MesoWest site for March 22, 2009 (<http://www.met.utah.edu/mesowest/>). Speeds at or above the blowing dust thresholds, Weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time in MDT (March 22)	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
23:55	34	86	6		60	overcast	10
22:55	34	86	9		310	overcast	6
21:55	34	86	17	25	270	overcast	5
20:55	41	56	15	25	250	mostly cloudy	10
19:55	46	42	7		250	overcast	10
18:55	52	26	22	29	290	overcast	10
17:55	55	21	14	25	230	mostly cloudy	10
16:55	55	16	25	47	210	mostly cloudy	10
15:55	63	14	36	43	230	clear	10
14:55	61	16	14	25	170	mostly clear	10
13:55	61	17	16	22	200	clear	10
12:55	61	18	21	31	220	partly cloudy	10
11:55	57	21	9	16	230	clear	10
10:55	55	24	18	24	240	clear	10
9:55	52	35	0			clear	10
8:55	46	53	8		30	clear	10
7:55	45	53	6		200	partly cloudy	10
6:55	43	61	12		130	overcast	10
5:55	43	61	13		110	clear	10
4:55	45	57	14	18	190	mostly clear	10
3:55	50	37	16	22	220	overcast	10
2:55	45	53	5		200	overcast	10
1:55	43	52	5		130	clear	10
0:55	46	46	8		120	mostly clear	10
0:15	45	49	10		120	clear	10

Table 3. Wind and weather observations for Alamosa, Colorado (about 64 miles east of Pagosa Springs) reported by the University of Utah MesoWest site for March 22, 2009 (<http://www.met.utah.edu/mesowest/>). Speeds at or above the blowing dust thresholds, Weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time in MST March 22	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
23:52	41	48	24	37	250	mostly cloudy	10
23:28	45	33	29	50	280	haze	6
23:16	45	31	36	50	260	haze	2.5
22:52	47	19	23	30	250	clear	10
21:52	50	17	23	30	260	clear	10
20:52	52	13	22	37	230	clear	10
19:52	53	23	16	27	200	clear	10
18:52	56	15	21	32	210	clear	10
17:52	60	11	27	40	200	clear	10
16:52	61	11	25	32	200	clear	10
15:52	62	11	30	37	220	clear	10
14:52	62	13	27	36	210	clear	10
13:52	62	13	21	30	220	clear	10
12:52	61	18	17	30	210	clear	10
11:52	58	22	21	29	230	clear	10
10:52	54	27	15		180	clear	10
9:52	52	28	14		180	clear	10
8:52	49	30	12		210	clear	10
7:52	45	34	13		200	clear	10
6:52	44	38	9		200	clear	10
5:52	47	37	10		180	mostly clear	10
4:52	50	32	29	36	240	mostly clear	10
3:52	45	36	9		210	clear	10
2:52	41	56	10		170	clear	10
1:52	45	51	10		200	clear	10
0:52	49	48	15		240	mostly cloudy	10

Table 4. Wind and weather observations for Durango, Colorado (about 42 miles west southwest of Pagosa Springs) reported by the University of Utah MesoWest site for March 22, 2009 (<http://www.met.utah.edu/mesowest/>). Speeds at or above the blowing dust thresholds, Weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time in MST March 22	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:00	34	86	23	30	270	lt snow; fog	1.5
23:53	35	85	15		250	lt snow; fog	6
23:49	36	80	16		250	lt snow	6
22:53	44	40	16	22	250	haze	5
22:28	43	45	8	18	270	haze	4
21:53	45	40	22	33	310	haze	3
21:46	45	39	23	39	310	haze	3
21:29	46	34	28	35	300	haze	2.5
21:19	48	29	18	27	300	haze	3
20:53	49	26	23	36	290	haze	5
19:53	56	12	22	43	240	mostly clear	8
18:53	59	12	25	39	210	clear	9
17:53	61	12	31	45	220	clear	9
16:53	64	11	29	51	210	clear	10
15:53	65	10	29	36	190	clear	10
14:53	63	13	22	28	180	clear	10
13:53	62	13	12		170	mostly clear	10
12:53	61	17	9	21	160	clear	10
11:53	60	17	12	20	220	clear	10
10:53	55	32	4			clear	10
9:53	52	35	0			clear	10
8:53	45	45	6		80	clear	10
7:53	41	53	7		70	clear	10
6:53	40	59	4		30	clear	10
5:53	42	55	4		30	mostly clear	10
4:53	45	47	0			mostly cloudy	10
3:53	44	51	4		10	partly cloudy	10
2:53	45	49	4		40	overcast	10
1:53	47	44	4		340	clear	10
0:53	48	42	4		360	mostly clear	10

Table 5. Wind and weather observations for Lamar, Colorado reported by the University of Utah MesoWest site for March 22, 2009 (<http://www.met.utah.edu/mesowest/>). Speeds at or above the blowing dust thresholds, weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time in MST March 22	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
23:53	63	34	36	47	210	clear	10
22:53	63	29	32	43	200	clear	10
21:53	64	29	25	33	190	clear	10
20:53	67	25	29	37	200	clear	10
19:53	68	27	24	36	180	clear	10
18:53	73	22	27	37	180	clear	10
17:53	77	20	30	40	190	clear	10
16:53	81	8	17	22	230	clear	10
15:53	81	9	16	31	240	clear	10
14:53	78	10	20		250	clear	10
13:53	77	11	14		250	clear	10
12:53	76	14	10		230	clear	10
11:53	76	14	17	29	270	clear	10
10:53	68	27	16		240	clear	10
9:53	63	38	17		230	clear	10
8:53	61	44	17		230	clear	10
7:53	57	55	18		230	clear	10
6:53	54	64	17		220	clear	10
5:53	56	64	22		220	clear	10
4:53	57	64	25	36	210	clear	10
3:53	57	64	33	44	200	clear	10
2:53	59	62	32	47	200	clear	10
1:53	59	62	32	45	200	clear	10
0:53	60	53	25	32	190	clear	10

Table 6. Wind and weather observations for Farmington, New Mexico (about 76 miles southwest of Pagosa Springs) reported by the University of Utah MesoWest site for March 22, 2009 (<http://www.met.utah.edu/mesowest/>). Speeds at or above the blowing dust thresholds, Weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time in MST March 22	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
23:53	33	96	20	27	290	lt snow; haze	1.25
23:42	34	93	15		300	lt snow; haze	2
23:29	36	93	22	31	290	lt rain; haze	6
23:22	37	87	23	33	290	lt rain; haze	10
22:53	41	67	23	35	290	haze	10
22:11	46	46	22	31	280	haze	10
21:53	46	47	20	32	290	haze	6
20:53	50	34	21	30	300	haze	6
20:33	52	30	27	38	310	haze	6
20:15	54	26	27	44	290	haze	5
19:53	60	10	35	54	230	overcast	3
19:37	61	11	40	51	240	haze	4
19:30	61	11	25	40	250	haze	2.5
19:06	63	9	36	55	230	haze	1
18:53	64	10	37	51	230	haze	2.5
18:29	64	10	37	47	230	haze	2.5
18:11	66	10	30	50	220	haze	2.5
17:53	68	10	31	46	220	haze	4
16:53	70	10	27	38	210	clear	8
15:53	71	10	31	40	210	clear	10
14:53	71	8	27	36	200	clear	10
13:53	71	8	20	30	220	clear	10
12:53	68	12	16	35	220	clear	10
11:53	65	14	8		150	clear	10
10:53	62	22	6			clear	10
9:53	57	30	4			clear	10
8:53	51	41	7		10	clear	10
7:53	51	39	4		110	clear	10
6:53	56	31	12		230	clear	10
5:53	57	31	12		240	clear	10
4:53	56	29	0			clear	10
3:53	55	30	5		90	clear	10
2:53	57	25	4		260	clear	10
1:53	58	26	5		210	mostly clear	10
0:53	61	21	14		220	clear	10

Table 7. Wind and weather observations for Gallup, New Mexico (about 156 miles southwest of Pagosa Springs) reported by the University of Utah MesoWest site for March 22, 2009 (<http://www.met.utah.edu/mesowest/>). Speeds at or above the blowing dust thresholds, Weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time in MST March 22	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
23:53	35	72	21	31	300	lt snow	10
22:53	45	30	31	48	250	clear	10
21:53	49	23	29	47	250	mostly cloudy	10
20:53	53	22	33	48	230	mostly cloudy	10
19:53	54	18	29	45	240	mostly clear	10
18:53	57	14	32	50	230	clear	10
17:53	62	12	36	50	220	clear	10
16:53	65	11	28	48	220	clear	10
15:53	66	10	36	50	210	clear	10
14:53	65	11	28	40	230	clear	10
13:53	64	15	29	38	210	clear	10
12:53	63	15	23	36	220	clear	10
11:53	60	18	25	31	240	clear	10
10:53	58	22	18	25	220	clear	10
9:53	53	28	17	28	220	clear	10
8:53	50	36	16	21	210	clear	10
7:53	47	42	10		200	clear	10
6:53	46	47	7		200	clear	10
5:53	46	47	8		210	clear	10
4:53	49	42	8		220	clear	10
3:53	49	41	12		230	clear	10
2:53	48	42	9		210	clear	10
1:53	47	40	8		190	mostly clear	10
0:53	49	36	6		210	clear	10

Table 8. Wind and weather observations for Kykotsmovi Village, Arizona (about 225 miles southwest of Pagosa Springs) reported by the University of Utah MesoWest site) for March 22, 2009

(<http://www.met.utah.edu/mesowest/>). Speeds at or above the blowing dust thresholds, Weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time in MST March 22	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
23:13	31	73	15	24	269		
22:13	34	72	19	29	273		
21:13	34	92	17	38	277		
20:13	33	85	25	40	302		
19:13	43	55	28	47	296		
18:13	54	21	34	50	224		
17:13	56	17	39	54	225		
16:13	60	14	38	61	236		
15:13	61	11	42	60	232		
14:13	64	12	40	56	219		
13:13	64	11	39	55	225		
12:13	65	12	33	46	214		
11:13	63	13	27	40	219		
10:13	60	17	18	31	209		
9:13	58	23	19	28	192		
8:13	53	39	13	18	191		
7:13	33	71	4	8	47		
6:13	33	62	5	6	43		
5:13	38	59	5	6	37		
4:13	40	51	1	5	18		
3:13	44	47	1	7	115		
2:13	49	41	6	10	216		
1:13	49	38	6	15	271		
0:13	54	35	10	15	208		

Table 9. Wind and weather observations for Window Rock, Arizona (about 160 miles southwest of Pagosa Springs) reported by the University of Utah MesoWest site for March 22, 2009 (<http://www.met.utah.edu/mesowest/>). Speeds at or above the blowing dust thresholds, Weather, and visibility (caused by or reduced by dust) have been highlighted in yellow

Time in MST March 22	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
23:58	30	86	15	21	280	lt snow	3
23:53	30	88	10	18	280	lt snow; fog	2.5
23:50	30	86	9	18	280	lt snow; fog	2
23:43	30	86	13		280	lt snow; fog	1
23:18	32	86	23	29	300	lt snow; fog	1.75
23:10	36	80	15		270	lt snow	5
22:53	37	72	17	29	270	unknown prcp	10
22:32	39	65	20	30	290	mostly cloudy	10
21:53	45	27	33	55	230	clear	10
20:53	48	21	31	45	250	mostly cloudy	7
19:53	51	20	24	40	230	mostly cloudy	8
18:53	54	15	33	53	230	clear	10
17:53	58	14	28	47	220	clear	10
16:53	61	13	31	50	210	clear	9
15:53	62	12	36	50	210	clear	10
14:53	64	13	28	41	200	clear	10
13:53	62	14	24	37	210	clear	10
12:53	60	17	22	36	220	clear	10
11:53	58	18	21	35	230	clear	10
10:53	55	22	16	27	220	clear	10
9:53	51	32	13	18	190	clear	10
8:53	46	42	9	17	170	clear	10
7:53	43	49	6		110	clear	10
6:53	44	49	6		170	clear	10
5:53	45	45	4		180	clear	10
4:53	45	47	6		180	clear	10
3:53	46	43	7		180	clear	10
2:53	46	42	5		180	clear	10
1:53	45	42	0			mostly clear	10
0:53	48	35	4		180	mostly clear	10

Table 10. Wind and weather observations for Winslow, Arizona (about 260 miles southwest of Pagosa Springs) reported by the University of Utah MesoWest site for March 22, 2009 (<http://www.met.utah.edu/mesowest/>). Speeds at or above the blowing dust thresholds, Weather, and visibility (caused by or reduced by dust) have been highlighted in yellow.

Time in MST March 22	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
23:56	41	36	16		270	overcast	10
22:56	39	55	15		310	overcast	10
21:56	38	73	18	29	330	overcast	10
21:18	43	61	14	27	330	overcast	10
20:56	51	32	28	45	240	overcast	10
19:56	52	28	24	35	230	clear	10
18:56	55	18	31	51	220	clear	10
17:56	59	14	38	56	210	clear	8
16:56	64	12	38	59	200	clear	10
15:56	66	10	48	62	200	haze	4
14:56	68	13	44	58	190	clear	10
13:56	69	11	44	58	200	clear	10
12:56	70	12	36	51	200	clear	10
11:56	69	12	38	51	210	clear	8
10:56	68	13	32	41	210	clear	10
9:56	66	14	25	33	190		
8:56	61	18	14	21	180	clear	10
7:56	50	32	8		140	clear	10
6:56	42	44	6		90	clear	10
5:56	45	42	7		130	clear	10
4:56	47	40	8		90	clear	10
3:56	46	43	6		130	clear	10
2:56	44	49	6		90	clear	10
1:56	45	45	5		110	clear	10
0:56	49	39	5		140	clear	10

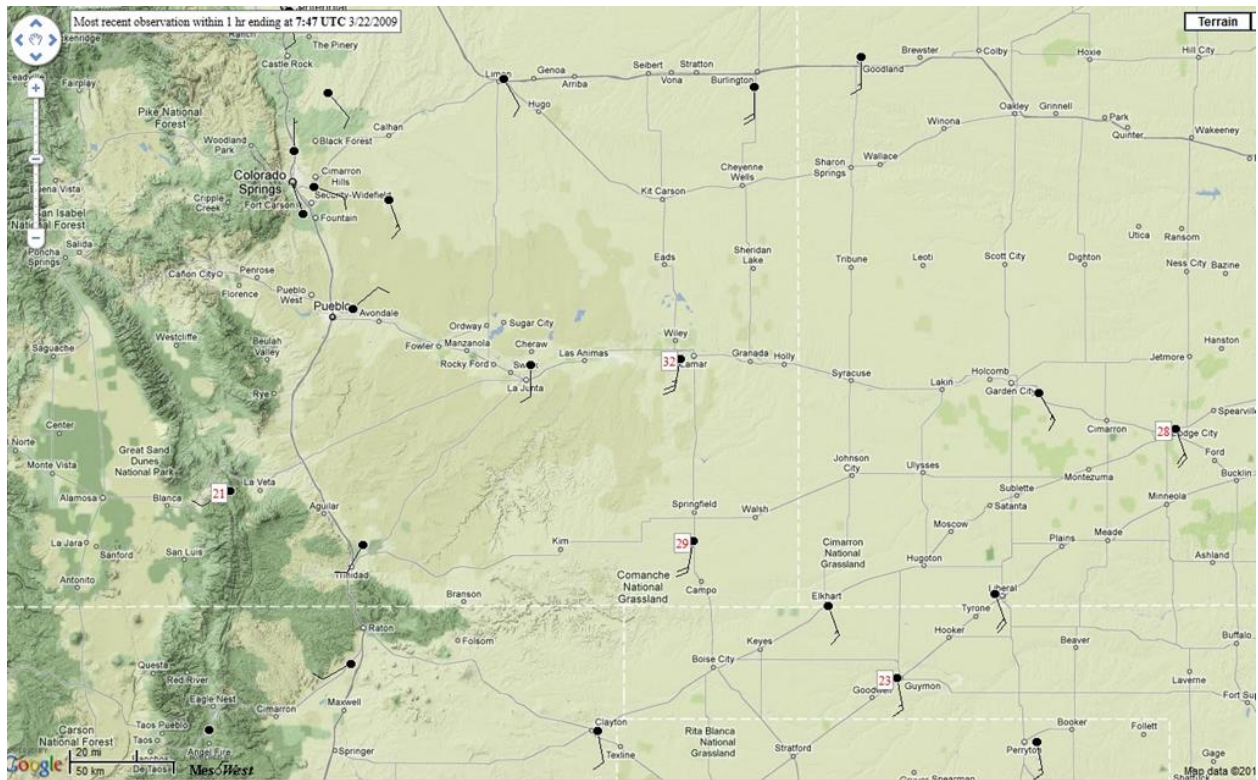


Figure 24. Wind directions and gust speeds caused by low-level jet over the Great Plains at 7:47Z March 22, 2009 or 12:47 AM MST on March 22, 2009 (<http://www.met.utah.edu/mesowest/>).

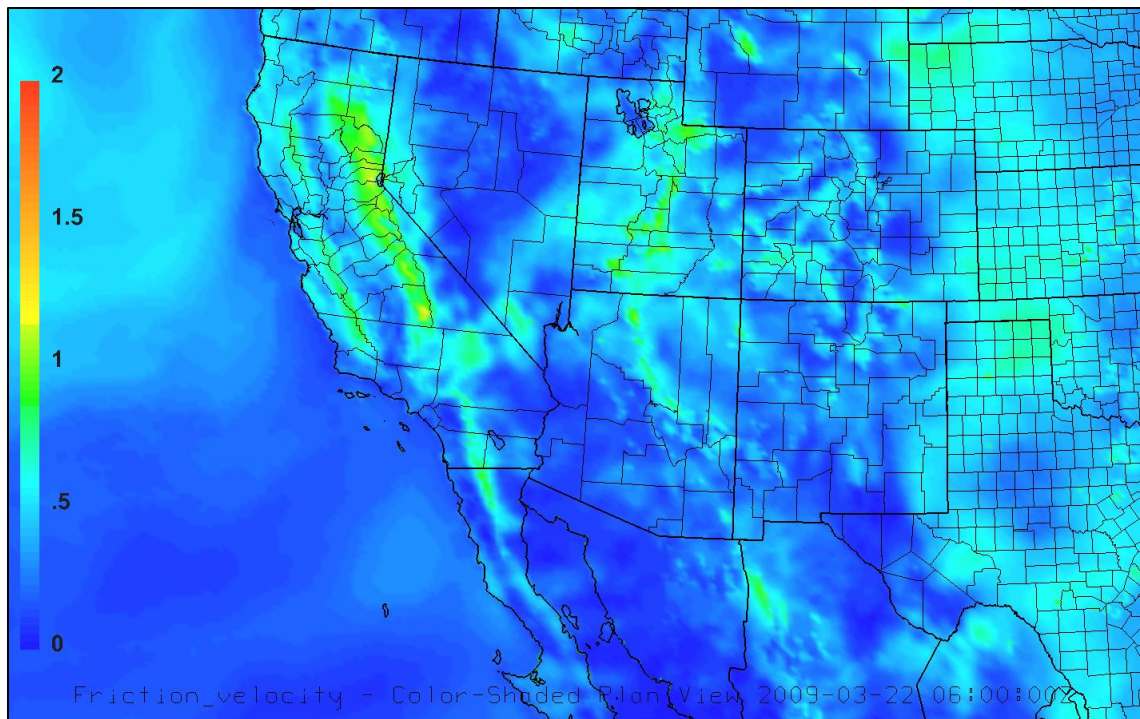


Figure 25. Friction velocities in meters/second from the NOAA NCEP North American Model with 12 kilometer grid spacing at 6Z March 22, 2009 (11 PM MST March 21).

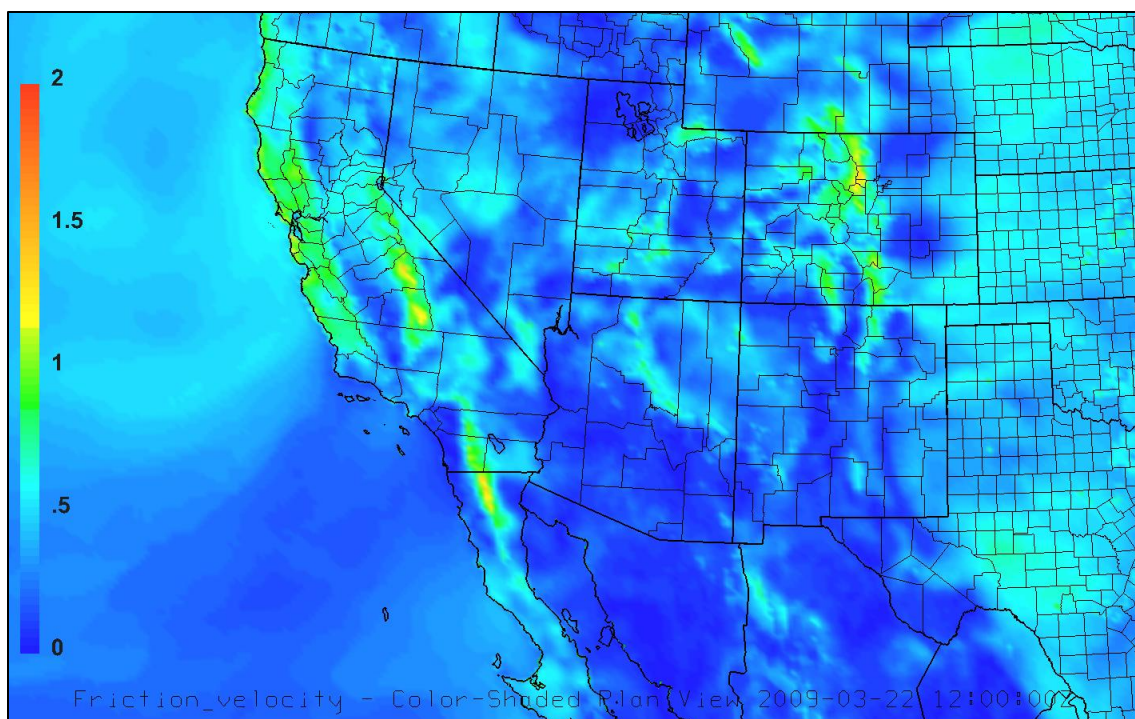


Figure 26. Friction velocities in meters/second from the NOAA NCEP North American Model with 12 kilometer grid spacing at 12Z March 22, 2009 (5 AM MST March 22).

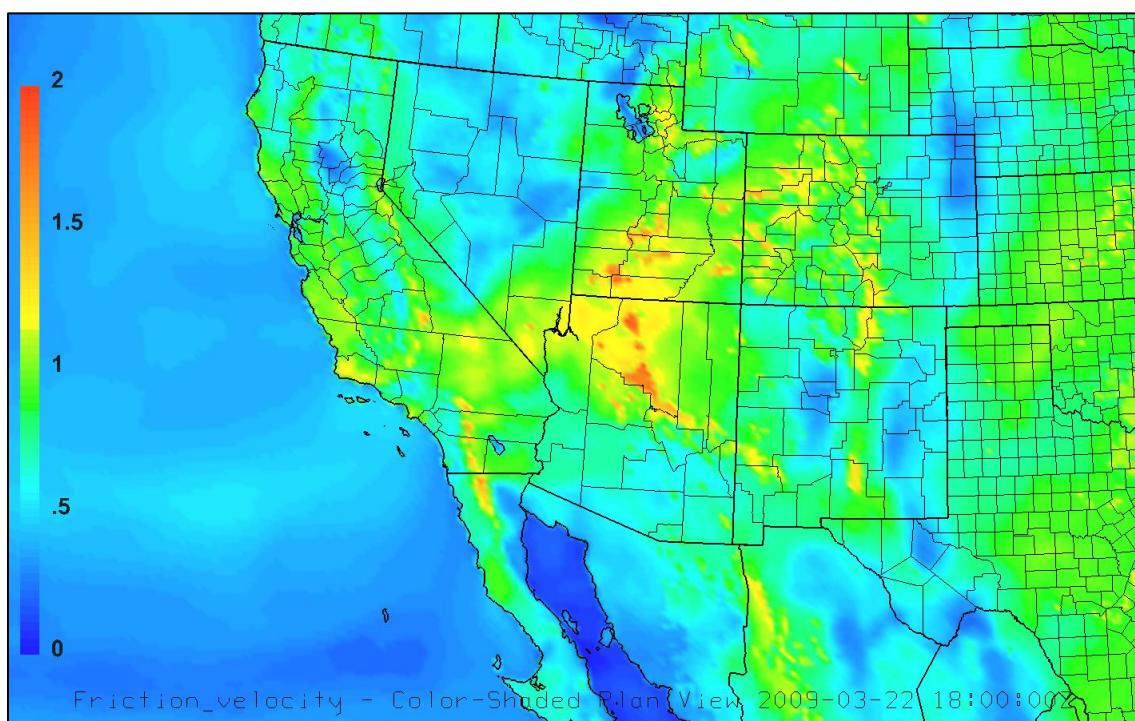


Figure 27. Friction velocities in meters/second from the NOAA NCEP North American Model with 12 kilometer grid spacing at 18Z March 22, 2009 (11 AM MST March 22).

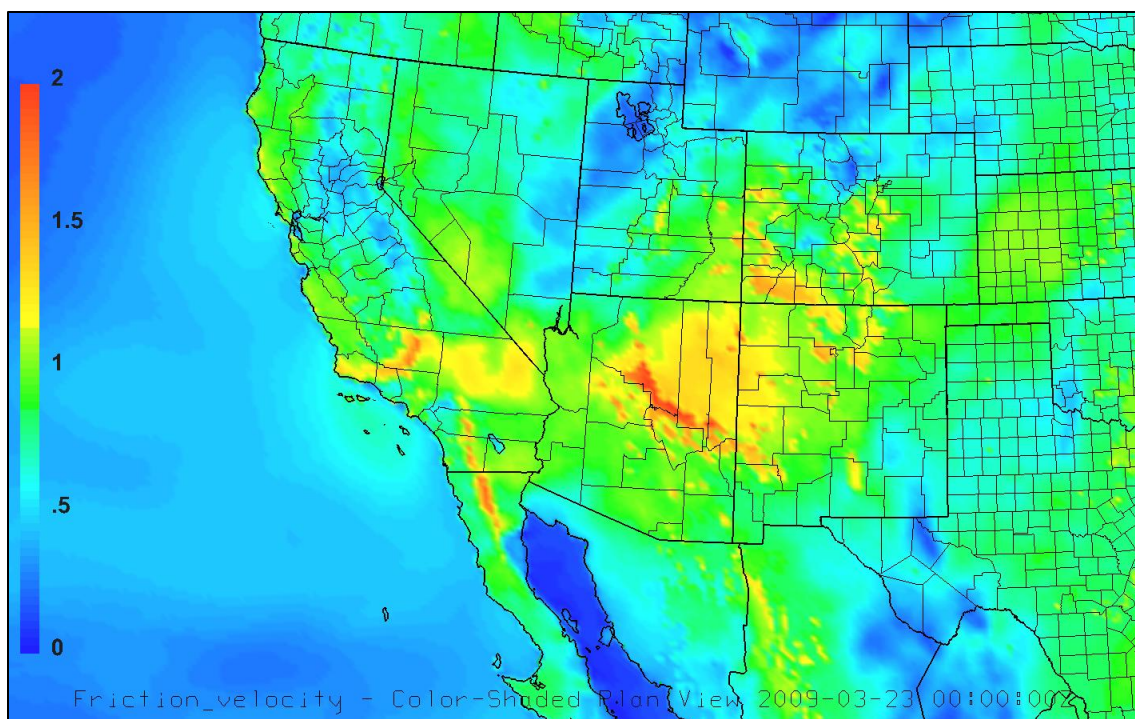


Figure 28. Friction velocities in meters/second from the NOAA NCEP North American Model with 12 kilometer grid spacing at 0Z March 23, 2009 (5 PM MST March 22).

Wind Advisories issued by the NWS Forecast offices in Grand Junction, Colorado; Flagstaff, Arizona; and Albuquerque, New Mexico, for western Colorado, eastern Utah, northeast Arizona, and northwest New Mexico are presented in Attachment D. They show that strong winds and areas of blowing dust were expected to occur on March 22, 2009, throughout much of northeast Arizona, northwest New Mexico, western Utah, and western Colorado.

The Center for Snow and Avalanche Studies (<http://www.snowstudies.org/index.html>) has been studying the effects of desert dust deposition on snowpack albedo and snowmelt in the San Juan Mountains of Colorado. Figure 29 contains the center's log of events that deposited dust on the snowpack of the San Juan Mountains. It lists March 22, 2009, as one of twelve Dust-on-Snow events for the 2008/2009 water year.

Figure 30 shows a MODIS true color satellite image centered on Arizona on March 22, 2009, at 21:18Z (2:18 PM MST March 22) (from the United States Forest Service site at <http://activefiremaps.fs.fed.us/imagery.php?op=fire&fireID=az-000>). It shows a large, dense area of blowing dust over northeast Arizona and the Four Corners area including the Painted Desert and Little Colorado River Valley region. The area of blowing dust includes plumes of dust oriented along southwest to northeast lines consistent with the transport flow described in other products presented in this report. The area of blowing dust in the MODIS satellite picture in Figure 30 is in the middle of the matrix used for the forward trajectories in Figures 19 through 22.

Figure 31 contains the Descriptive Text Narrative for Smoke/Dust Observed in Satellite Imagery from NOAA's Satellite Services Division through 0045Z March 23 ([Smoke Text Product - Satellite Services Division](#)). It describes blowing dust moving from Arizona into southwest Colorado. Kykotsmovi Village is in the middle of the area of blowing dust in the MODIS satellite picture in Figure 30. The observations

in Table 8 from Kykotsmovi Village have ten hours of wind speeds at or above blowing dust thresholds of 25 mph and or wind gusts of 40 mph. Table 10 has the observations for Winslow, Arizona, which is on the south side of the area where dust is being lifted into the atmosphere. It has eleven hours of wind speeds at or above the blowing dust thresholds of 25 and or wind gusts of 40. The National Weather Service observations from Durango, Colorado, and Farmington, New Mexico, in Tables 4 and 6 both have six hours of observations with visibilities reduced due to haze. This haze is caused by the dust being transported from northeast Arizona and northwest New Mexico. Note both stations have additional hours of reduced visibility after the frontal passage due to increased relative humidity levels.

Figure 32 shows the output for dust from the NAAPS (Navy Aerosol Analysis and Prediction System) Global Aerosol Model for March 22, 2009 (<http://www.nrlmry.navy.mil/aerosol/>). It shows a large area of blowing dust over northern Arizona moving over much of Colorado by 11 PM on March 22, 2009. The NAAPS model output is based on soil moisture content, soil erodibility factors, and modeled meteorological factors conducive to blowing dust (for a description of NAAPS see: http://www.nrlmry.navy.mil/aerosol_web/Docs/globaer_model.html). Although the NAAPS forecast products can over predict dust PM_{10} , they do provide an independent calculation of the potential for blowing dust and the spatial extent of blowing dust for this event. The highest NAAPS concentrations of dust PM_{10} are in northeastern Arizona. All of the products discussed in this report point to a widespread, regional-scale dust storm that originated in portions of Arizona and grew to cover most of Colorado.

**Colorado Dust-on-Snow (CODOS)
Dust-on-Snow Deposition Events Log**

Thanks to our original National Science Foundation research grants for collaborative research (grants ATM-0432327 to Painter at National Snow and Ice Data Center and ATM-0431955 to Landry at Center for Snow and Avalanche Studies), and to the subsequent support of the emergent Colorado Dust-on-Snow program by Colorado water districts, this program has accumulated several seasons of dust-on-snow observations at our Senator Beck Basin Study Area (SBBSA) at Red Mountain Pass, summarized in the table below. It is reasonable to assume that our skill at detecting dust-on-snow events has improved and that we may have failed to observe very small events during the early years of this work. Therefore the table represents an absence of events in grey for the first two years of observation but thereafter indicates an absence of observed events as “0” (zero).

**Dust-on-Snow Events Documented per Month, by Winter
Senator Beck Basin Study Area at Red Mountain Pass – San Juan Mountains**

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
2002/2003					2		1			3
2003/2004							2	1		3
2004/2005	0	0	0	0	0	1	2	1	0	4
2005/2006	0	0	1	0	1	1	3	2	0	8
2006/2007	0	0	1	0	1	1	3	1	1	8
2007/2008	0	0	0	0	0	3	3	1	0	7
2008/2009	1	0	1	0	1	4	5	0	0	12

Dates of the events, by winter/spring season, were as follows (WY = Water Year):

2002/2003 (WY2003): Feb 3, Feb 22, Apr 2-3

2003/2004 (WY 2004): Apr 17, Apr 28, May 11

2004/2005 (WY 2005): Mar 23, Apr 4, Apr 8, May 9

2005/2006 (WY 2006): Dec 23, Feb 15, Mar 26, Apr 5, Apr 15, Apr 17, May 22, May 27

2006/2007 (WY 2007): Dec 17, Feb 27, Mar 27, Apr 15, Apr 18, Apr 24, May 4, Jun 6

2007/2008 (WY 2008): Mar 16, Mar 26-27, Mar 30-31, Apr 15, Apr 21, Apr 30, May 12

2008/2009 (WY 2009): Oct 11, Dec 13, Feb 27, Mar 6, Mar 9, Mar 22, Mar 29, Apr 3, Apr 8, Apr 15, Apr 24, Apr 25

Figure 29. Dust-on-Snow Deposition Events Log at the Senator Beck Basin Study Area on Red Mountain Pass, Colorado. (The Center for Snow and Avalanche Studies, <http://www.snowstudies.org/index.html>)

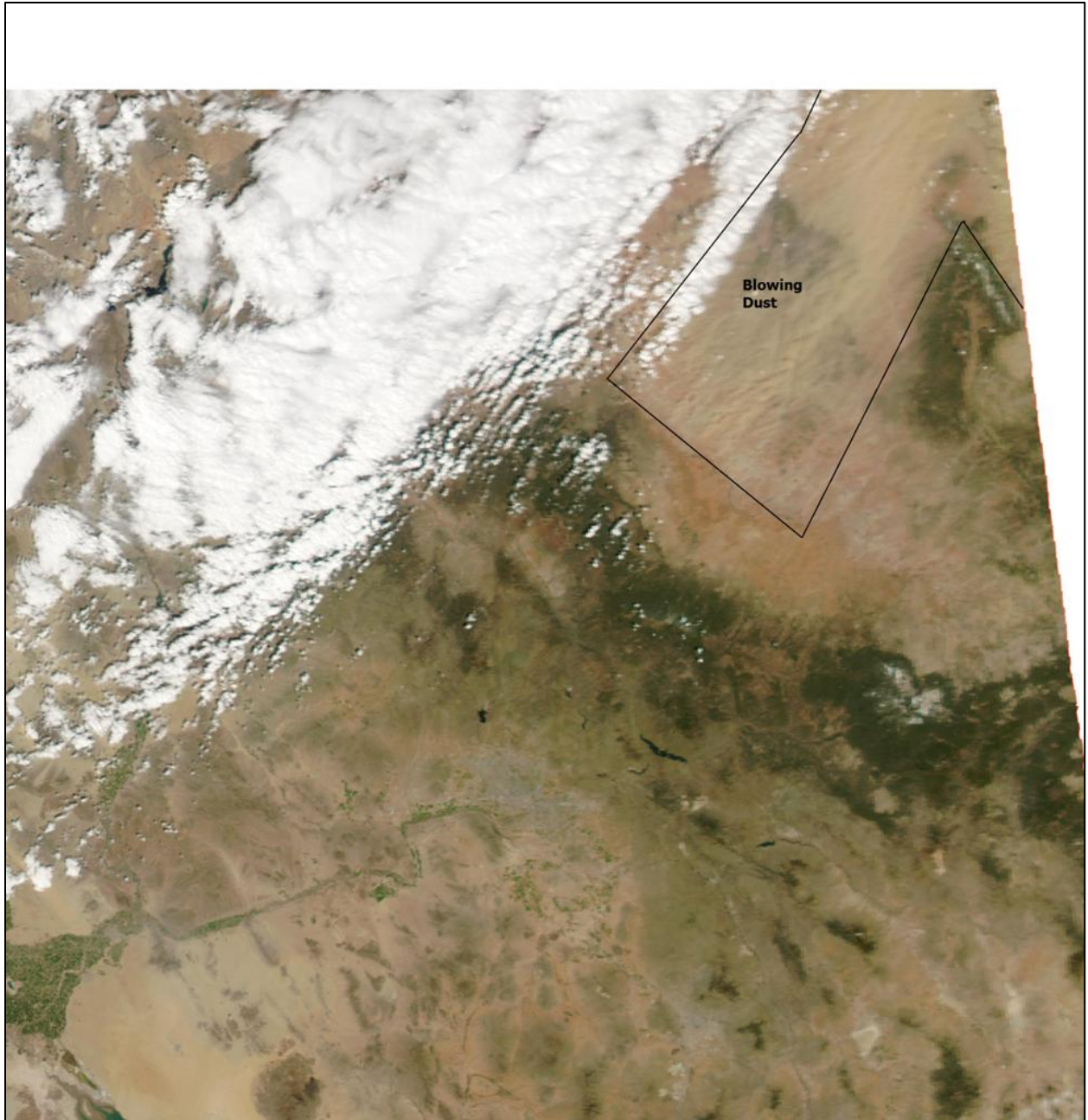


Figure 30. MODIS satellite image centered on Arizona at 21:18Z March 22, 2009 (2:18 PM MST March 22, 2009, <http://activefiremaps.fs.fed.us/imagery.php>) showing widespread blowing dust over the Painted Desert and Little Colorado River Valley region of the state.

SUNDAY MARCH 22, 2009

**DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY
THROUGH 0045Z MARCH 23, 2009**

California:

In San Bernardino and Inyo counties, blowing dust is moving rapidly to the east into far southern Nevada.

Arizona:

In Navajo and Apache counties, blowing dust is moving quite fast into northwest New Mexico, far southeastern Utah, and southwest Colorado.

In Louisiana and Mississippi, a couple dense smoke plumes were observed moving to the north and west.

THE FORMAT OF THIS TEXT PRODUCT IS BEING MODIFIED. IT WILL NO LONGER DESCRIBE THE VARIOUS PLUMES THAT ARE ASSOCIATED WITH ACTIVE FIRES. THESE PLUMES ARE DEPICTED IN VARIOUS GRAPHIC FORMATS ON OUR WEB SITE:

JPEG: <http://www.ssd.noaa.gov/PS/FIRE/hms.html>
GIS: <http://www.firedetect.noaa.gov/viewer.htm>
KML: <http://www.ssd.noaa.gov/PS/FIRE/kml.html>

THIS TEXT PRODUCT WILL CONTINUE TO DESCRIBE SIGNIFICANT AREAS OF SMOKE WHICH HAVE BECOME DETACHED FROM AND DRIFTED SOME DISTANCE AWAY FROM THE SOURCE FIRE, TYPICALLY OVER THE COURSE OF ONE OR MORE DAYS. IT WILL ALSO STILL INCLUDE DESCRIPTIONS OF BLOWING DUST.

ANY QUESTIONS OR COMMENTS REGARDING THESE CHANGES OR THE SMOKE TEXT PRODUCT IN GENERAL SHOULD BE SENT TO SSDFireTeam@noaa.gov

Figure 31. Smoke Text Product Satellite Services Division, Descriptive Text Narrative for Smoke/Dust observed in satellite imagery through 0045Z March 22, 2009 ([Smoke Text Product - Satellite Services Division](#)).

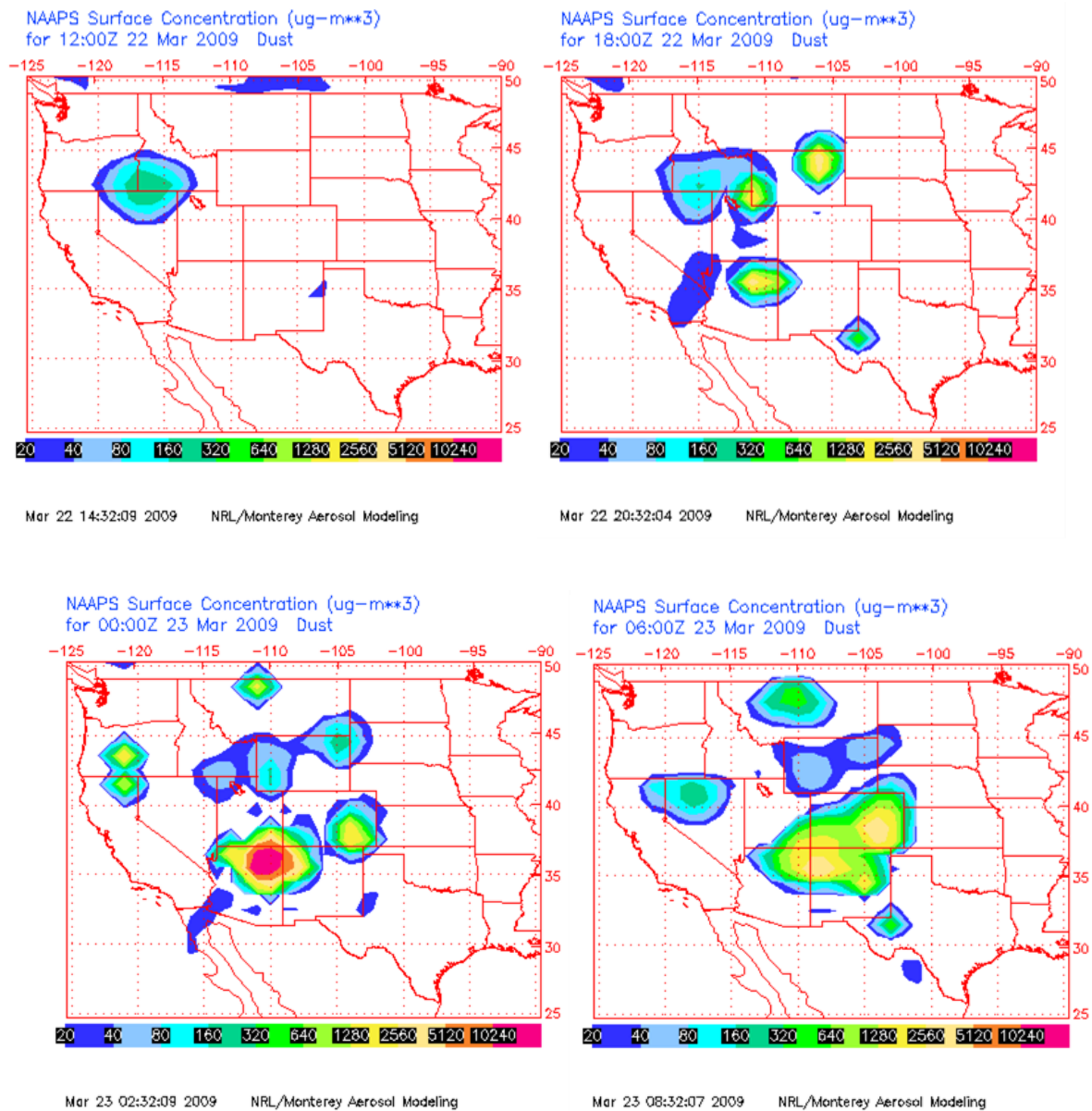


Figure 32. NAAPS forecasted dust concentrations for March 22, 2009 (source: http://www.nrlmry.navy.mil/flambe-bin/aerosol/display_directory_aer2?DIR=/web/aerosol/public_html/globaer/ops_01/wus/).

3.0 Ambient Monitoring Data and Statistics

A PM₁₀ concentration that exceeded the level of the twenty-four-hour NAAQS was monitored in Pagosa Springs, Colorado on Sunday March 22, 2009. An exceedance of 255 µg/m³ was recorded at the Pagosa Springs Middle School monitoring site. This exceedance was caused by a nature; a regional dust storm that was not preventable or reasonably controllable. The spatial extent of this dust storm was from the deserts of northeastern Arizona and northwestern New Mexico through the southern and central portions of Colorado (see section 2). This weather system adversely affected the air quality in Pagosa Springs and had a negative impact on PM₁₀ concentrations at several other monitoring stations in Colorado, including Mount Crested Butte, Lamar and even a small impact on Steamboat Springs. Unfortunately, this was not a once every three-day sampling day; thus, the high PM₁₀ was only captured by the daily monitoring sites, which make up less than one third of the PM₁₀ network. See figure 1 in section 2, (PM10 High event in Colorado) for a map of all the valid PM₁₀ concentrations recorded in Colorado on March 22, 2009. The 255 µg/m³ at Pagosa Springs was the only site greater than the NAAQS of 150 µg/m³.

Monitored PM₁₀ levels before and after the March 22, 2009 episode were low as can be seen in Table 1 and Figure 33. The APCD reviewed PM₁₀ monitoring data in Pagosa Springs and the surrounding areas in the path of the dust storm (see section 3.1). The PM₁₀ concentrations in Pagosa Springs on March 22, 2009 were compared to the concentrations on the days before and the days after the regional dust storm. Figure 33 clearly shows that the regional blowing dust storm adversely affected the air quality in Pagosa Springs. The days before and after the event were quite low with concentrations that are typical for winter in Pagosa Springs (see Table 11 and section 3.1, the Historical Fluctuations of PM₁₀ Concentrations in Pagosa Springs). Other PM₁₀ monitoring sites in Colorado had elevated PM₁₀ concentrations that were above their typical seasonal and historical concentrations on March 22, 2009 as explained in section 3.1 below, but these sites did not exceed the 24-hour NAAQS. All other Colorado sites recorded concentrations between 30 µg/m³ in Denver, which usually has low concentrations during these southwestern regional dust storm events, and 111 µg/m³ in Lamar on March 22, 2009. Also, the Alamosa Municipal Building site sample was invalid and the sample from the Alamosa Adams State College site was not significantly elevated. This is perfectly plausible as dust storms often have uneven concentrations and impact site differently even when they are geographically close to each other. For example, the two Lamar sites in Table 11 below are only separated by one mile of flat terrain, but their PM₁₀ concentrations on March 22, 2009 are significantly different (111 µg/m³ and 48 µg/m³). PM₁₀ concentrations are known to be highly localized.

Table 11. Pagosa Springs PM₁₀ Concentrations Before and After March 22, 2009 Regional Dust Storm.

Date	Pagosa Springs	Mount Crested Butte	Lamar Power Plant	Lamar Municipal
03/19/2009	39 µg/m ³	40 µg/m ³	43 µg/m ³	23 µg/m ³
03/20/2009	31 µg/m ³	42 µg/m ³	44 µg/m ³	35 µg/m ³
03/21/2009	29 µg/m ³	33 µg/m ³	73 µg/m ³	25µg/m ³
03/22/2009	255 µg/m³	93 µg/m³	111 µg/m³	48 µg/m³
03/23/2009	68 µg/m ³	16 µg/m ³	90 µg/m³	98µg/m³
03/24/2009	16 µg/m ³	14 µg/m ³	71 µg/m ³	70 µg/m ³
03/25/2009	24 µg/m ³	15 µg/m ³	40 µg/m ³	30 µg/m ³

The March 22, 2009 regional dust storm had a large spatial extent covering most of northeast Arizona, northwest New Mexico, and it moved into southern and central Colorado and was captured at the daily PM₁₀ sites from Pagosa Springs to Mount Crested Butte to Lamar. Since only daily PM₁₀ sites were operating on March 22, 2009 it is not possible to see many high PM₁₀ concentrations across the state. For

example, Durango and Telluride were in the path of the dust storm but were not monitoring on March 22, 2009. When the dust storm reached into Lamar located in southeast Colorado it was later in the evening and crossed over midnight into the early hours of the next day, March 23, 2009. That is why PM_{10} concentrations were still elevated in Lamar on March 23, 2009. There are also many weather stations across the path of the dust storm that recorded high winds and haze, which is blowing dust when there is no precipitation present. Most of these weather stations are located in areas that do not have PM_{10} monitoring sites. These meteorological stations can act as surrogates and help demonstrate the extent of the blowing dust in towns where there are no daily PM_{10} monitoring sites. See section 2 for the full meteorological details and extent of the regional dust storm.

Other data that shows the extent of the regional dust storm includes the Colorado Dust-on-Snow (CODOS) stations and news accounts and e-mails from credible eye witnesses. These sites record the date and other data when dust reached the high altitude monitoring stations (see Section 2 for details). March 22, 2009 was a dust on snow event according to the CODOS records (<http://www.snowstudies.org/CODOS/CSAS%20Dust-on-Snow%20Log.pdf>). The APCD also received a e-mails and pictures from credible eye witnesses in Aspen and Mount Crested Butte concerning a large dust storm that turned in to a dirty snow storm. These are shown in section 4.0 News Accounts and Credible Evidence. The town manager of Mt. Crested Butte, Joe Fitzpatrick, e-mailed Ray Mohr at the APCD that, "On March 22 and March 23, 2009 Mt. Crested Butte and Gunnison County experienced a major wind event with the front edge of this snow storm that blew a large amount of the red dust in from the desert. So we had red dust ahead of and mixed with our snow last Monday morning." And, Lee Cassin, the director of the Aspen/Pitkin Environmental Health Department, sent pictures of the dust on vehicles and an e-mail describing the event, "last night (March 22) we had a very unusual weather event, and our office has been getting calls from citizens and the media. We had winds the last couple of days (Sat. and Sun.), though not extremely strong. Last night around 8 or so, it started raining and then snowing, or rain mixed with snow. The next morning there was "brown snow" everywhere. It looked like snowplows had coated everything with brown road slush and sand. After the initial event, there was normal snow, but the first frozen rain/snow was completely brown..."

The time series graph in figure 33 shows the seasonal PM_{10} concentrations at the Pagosa Springs site during the months of March and April, 2009. The graph shows five regional blowing dust events that occurred that spring and impacted the town of Pagosa Springs. The PM_{10} concentrations on the days before and after the 22 March blowing dust event were quite low and this chart shows that event to be concentrated on that single day in Pagosa Springs. The other blowing dust events in March and April showed similar results; low PM_{10} concentrations before and after the blowing dust days. The town of Pagosa Springs at 7,103 ft. (2165 m) is located in a mountain valley topographic setting surrounded by mostly coniferous forests. There are very few anthropogenic local sources of geologic PM_{10} sized dust in the area as most of the area is covered in vegetation. Also, the anthropogenic sources are well controlled due to a State Implementation Plan (SIP) / PM_{10} Maintenance Plan. See section 5.0 Local Dust Controls for a comprehensive list of PM_{10} control measures employed in Pagosa Springs through the PM_{10} SIP / Maintenance Plan.

There is one blowing dust event in the Pagosa Springs time series charts below that needs further explanation. On April 8, 2009 there was a regional blowing dust event that impacted other areas of Colorado including the Alamosa Municipal Building site ($157 \mu\text{g}/\text{m}^3$) Alamosa Adams State College ($135 \mu\text{g}/\text{m}^3$), Breckenridge ($101 \mu\text{g}/\text{m}^3$), Steamboat Springs ($78 \mu\text{g}/\text{m}^3$), and Mount Crested Butte ($56 \mu\text{g}/\text{m}^3$). However, Pagosa Springs recorded a concentration of only $31 \mu\text{g}/\text{m}^3$ on April 8, 2009. Also, on April 6, 2009 Pagosa Springs recorded a concentration of $182 \mu\text{g}/\text{m}^3$, while all other sites in Colorado only recorded concentrations between $13 \mu\text{g}/\text{m}^3$ at Alamosa Adams State College to $40 \mu\text{g}/\text{m}^3$ at the Denver Visitor's Center site. After a thorough investigation and finding no meteorological reason for the

discrepancy, the Division believes the site operator failed to follow proper procedures and wrote the wrong dates on the chain of custody forms.

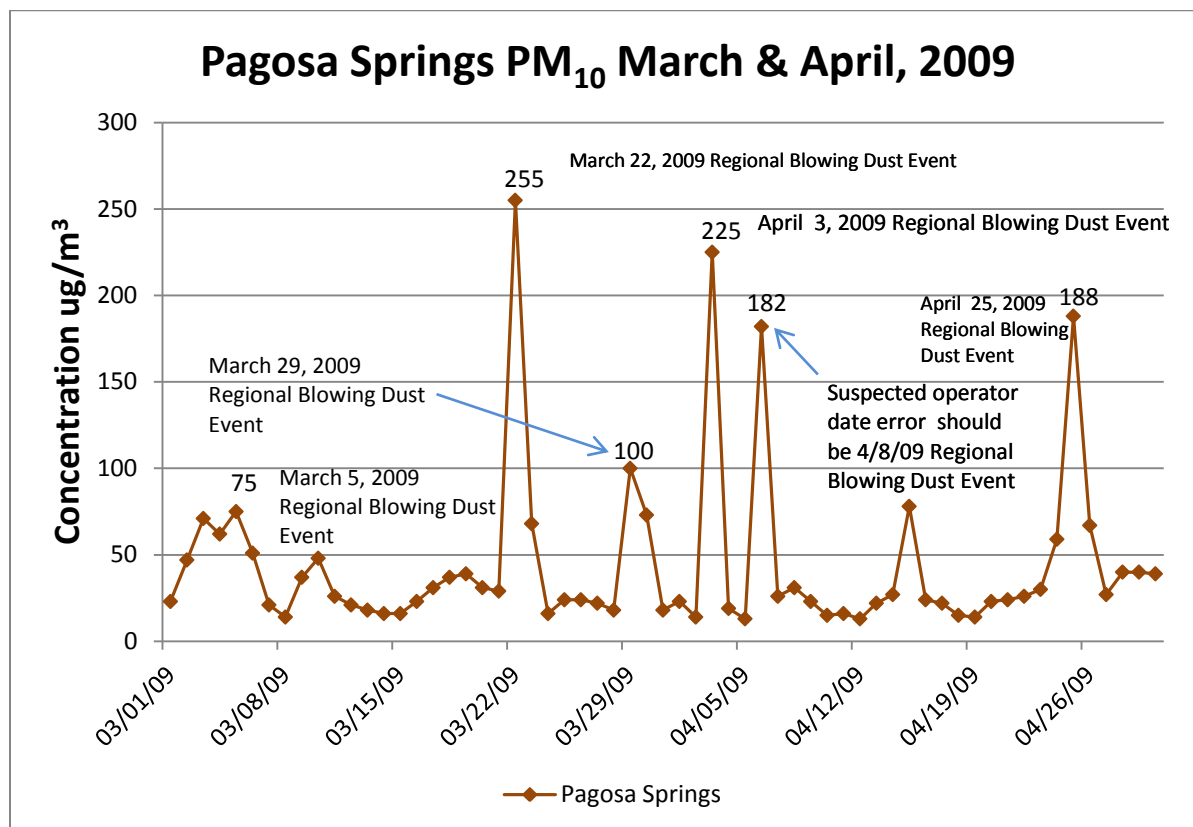


Figure 33. PM₁₀ Seasonal Concentrations in Pagosa Springs March and April, 2009.

From the limited PM₁₀ data (daily sites only) on March 22, 2009 in Pagosa Springs, Mount Crested Butte, Lamar, and Steamboat Springs before and after the high wind blowing dust event clearly shows that March 22, 2009 was a high PM₁₀ event. Furthermore, the regional blowing dust event on that day caused a PM₁₀ concentration that was much higher than normal for the two month (March and April) seasonal spring period of interest. Even though the PM₁₀ data for Pagosa Springs during the months of March and April shows three additional PM₁₀ exceedances, these were also caused by large naturally occurring regional blowing dust events that were not preventable or reasonably controllable. The March and April, 2009 period was exceptional in that it contains one of the most frequent regional blowing dust periods in the history of PM₁₀ monitoring in Colorado and was well documented by numerous sources. There were six regional blowing dust events in the two month period that covered large spatial areas of Colorado, Arizona and New Mexico and most of these will be documented in future exceptional event technical support documents by the APCD.

Steamboat Springs is different from most of the impacted sites as it is located farther away from the source area and in a relatively unique area of Colorado. Steamboat has the only state operated PM₁₀ monitoring station located in the northwestern area of the state and in the northern mountain region. Steamboat Springs is located 222 miles (357.4 km) north of Pagosa Springs with very complex terrain (13,000 – 14,000 foot peaks) and several mountain ranges between the two towns. Steamboat Springs is a ski area town and the PM₁₀ monitor is located at an elevation of 6,739 feet (2,054 m). Being that far north Steamboat is not usually impacted by the dust storms generated in the Four Corners region as they usually travel from the southwest to the northeast and east. Steamboat Springs is in a regime of its own.

Steamboat is also impacted by daily temperature inversions and stagnant air due to its mountain-valley topography and the town is located in a valley bottom setting on the western side of the Gore Range Mountains. The Gore Range blocks the typical westerly flow of air. Steamboat Springs has a PM₁₀ SIP Maintenance Plan that has required controls of geologic dust from the roads, such as using clean sand, sweeping highway 40, the main thoroughfare, immediately after sanding events. The Steamboat Springs SIP also has local restrictions on woodburning devices. (Reference: Steamboat Springs PM₁₀ Redesignation Request and Maintenance Plan – Adopted by the Colorado Air Quality Control Commission November 15, 2001) These control measures have kept the PM₁₀ concentrations well below the 24-hour NAAQS of 150 µg/m³. The remote northern location as well as the SIP control measures used in Steamboat Springs explains why the PM₁₀ concentration in Steamboat were only moderately elevated on March 22, 2009.

The elevated PM₁₀ concentrations in Mount Crested Butte (93 µg/m³), Lamar (109 µg/m³ and 49 µg/m³, Power Plant and Municipal Building sites, respectively), and in Steamboat Springs (54 µg/m³) on March 22, 2009 and the continuing high PM₁₀ concentrations on March 23, 2009 in Lamar (90 µg/m³ and 98 µg/m³, Power Plant and Municipal Building sites, respectively) provide additional direct evidence that the regional dust storm brought dust to other areas in Colorado. There were probably no other PM₁₀ exceedances recorded because the PM₁₀ daily network is sparse in this area of Colorado and dust storms do not have homogeneous deposition. A more robust network of PM₁₀ monitors on a daily frequency would likely have shown more exceedances or elevated concentrations from this natural blowing dust event. Section 2 provides the meteorological evidence for the spatial extent of this regional blowing dust event including the dust on snow data from the Colorado Dust-on-Snow (CODOS) network.

Figure 34 shows the annual PM₁₀ data for 2009. There were at least six regional blowing dust events identified by the Division that adversely affected the air quality in Pagosa Springs in 2009. Also, the data indicates that PM₁₀ is well controlled in Pagosa Springs. If it were not, there should be high PM₁₀ spikes during the winter when temperature inversions are strongest, which is common in Colorado mountain valley regimes. Instead, high PM₁₀ concentrations are only seen when winds are highest during regional dust storm events. All of these six dust storms originated in the Four Corners area from deserts in northeast Arizona and northwest New Mexico.

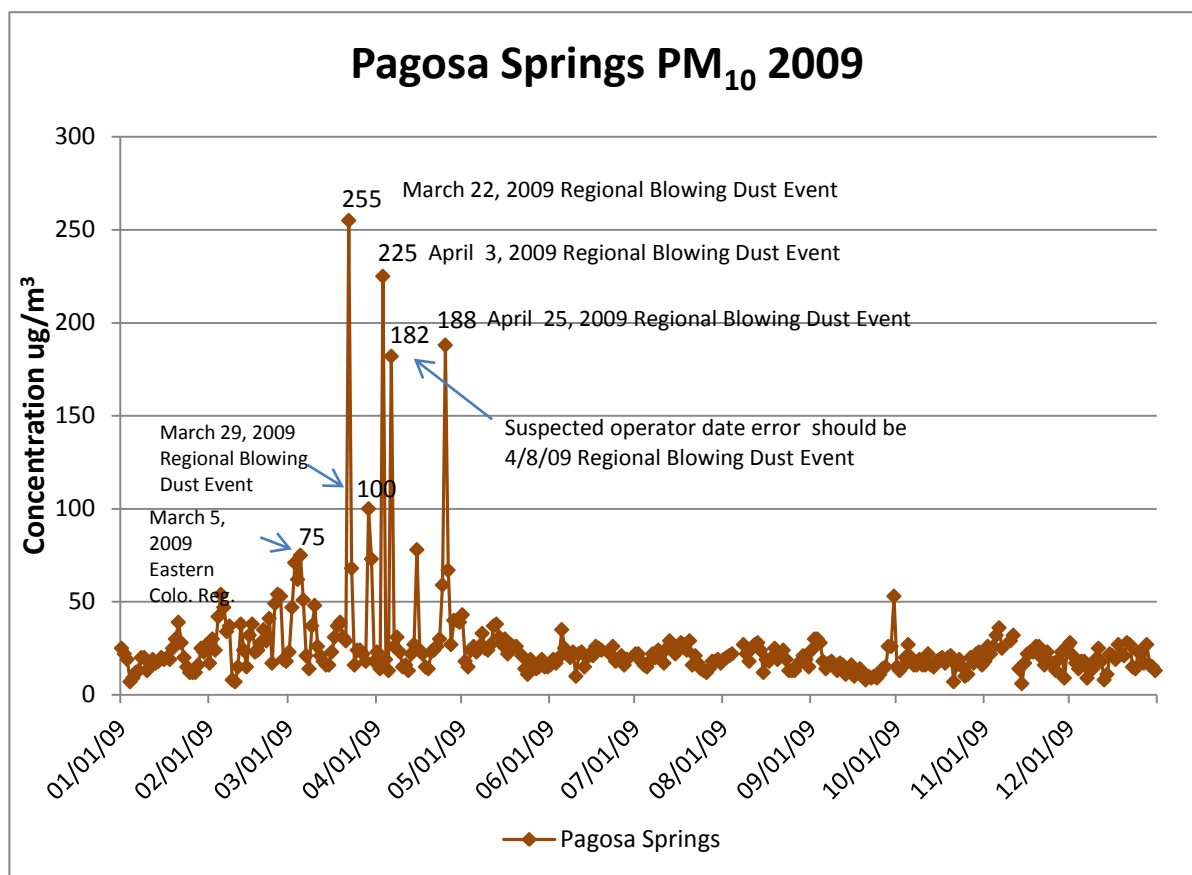


Figure 34. PM₁₀ Annual Concentrations in Pagosa Springs during 2009.

The following three time series charts in Figures 35 through 37 show the seasonal March and April 2009 PM₁₀ data Mount Crested Butte, Lamar, and Steamboat Springs, respectively. These charts present additional evidence that the regional dust storm brought elevated PM₁₀ concentrations to other areas of Colorado on March 22, 2009. The Pagosa Springs, Mount Crested Butte, and the Lamar annual data charts clearly show that the regional blowing dust storm adversely affected the air quality in those towns. This is not as evident in the Steamboat Springs annual data chart. But, the main reason for the difference is the distant location and direction from the source area as discussed above.

Mount Crested Butte is located 112 miles (182 km) north of Pagosa Springs with very complex terrain (13,000 – 14,000 foot peaks) between the two towns. Mount Crested Butte is a ski area town and the PM₁₀ monitor is located at an elevation of 9,403 feet (2,866 m).

CDPHE has a Memorandum of Agreement (MOA) in Mount Crested Butte to control dust from roads and other anthropogenic sources in the town. Furthermore, the Mount Crested Butte area was snow covered on March 22, 2009. The major sources of PM₁₀ in Crested Butte: re-entrained dust from local streets (there are no major streets or highways in town) and residential wood burning. The largest contributor is re-entrained dust and the street dust was likely well controlled due to the controls in the MOA (using more durable sand and magnesium chloride to reduce dust on parking lots, more frequent street sweeping, and a construction ordinance to reduce mud and dirt carry-out on streets). (Reference: Mount Crested Butte, Memorandum of Agreement, Effective March 5, 1998)

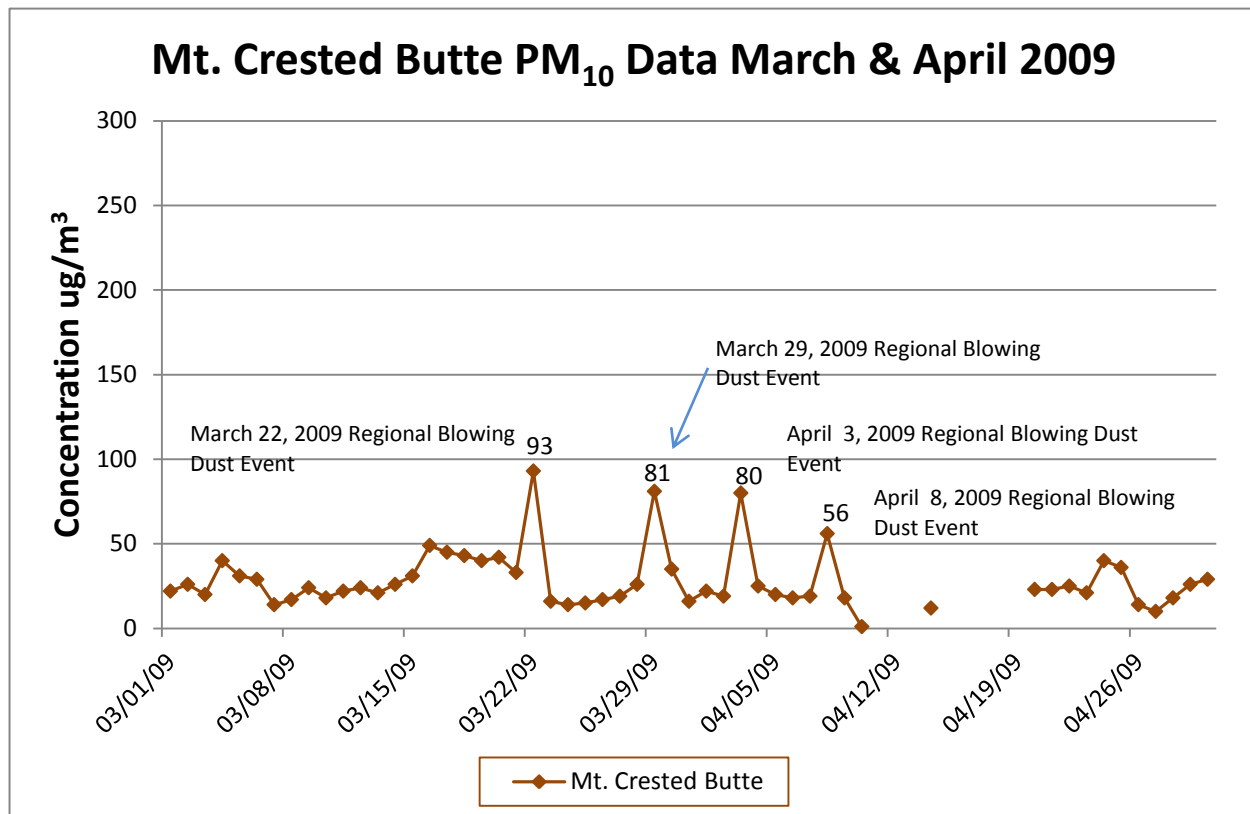


Figure 35. PM₁₀ Seasonal Concentrations in Mount Crested Butte, March and April, 2009.

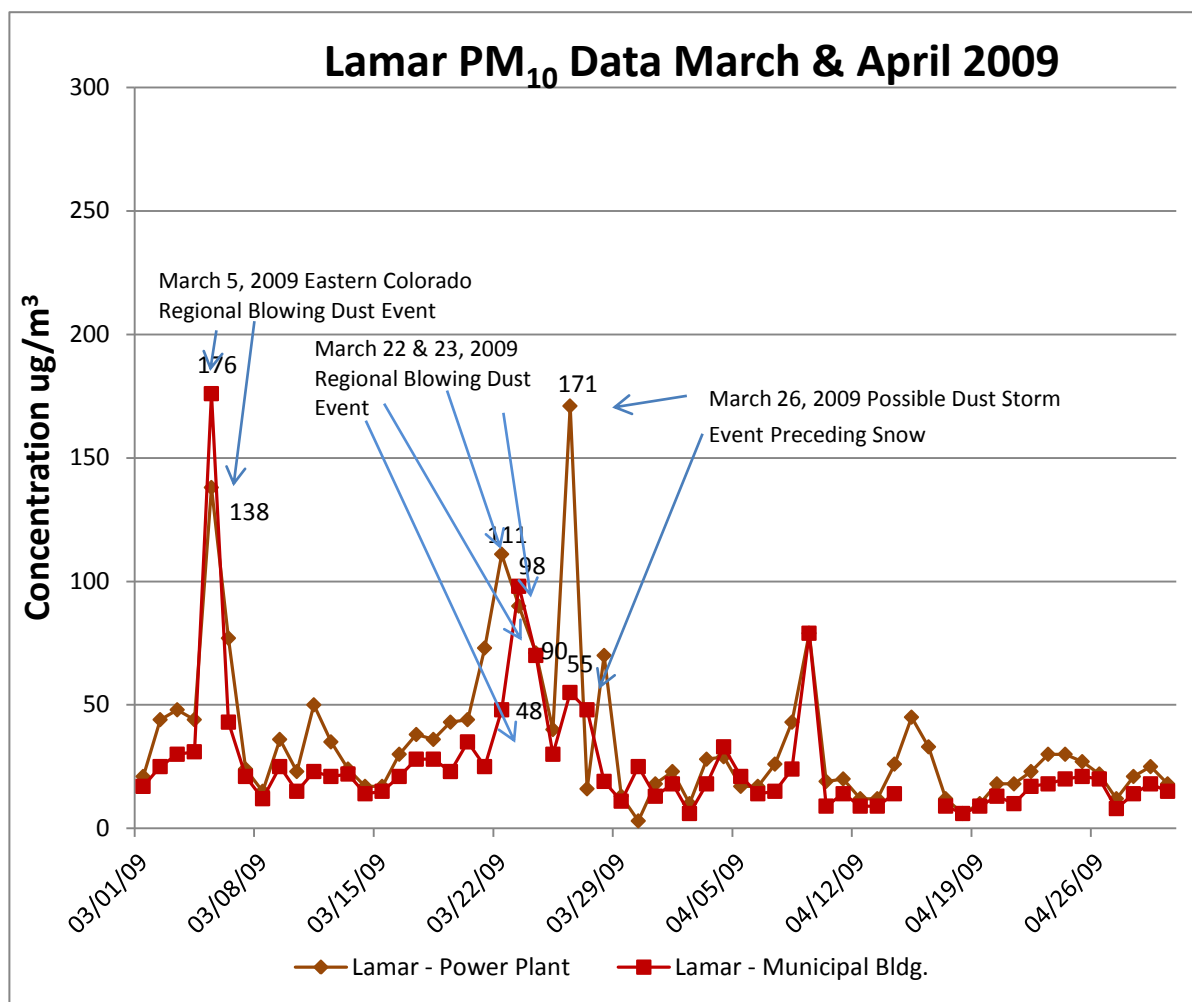


Figure 36. PM₁₀ Seasonal Concentrations in Lamar, March and April, 2009.

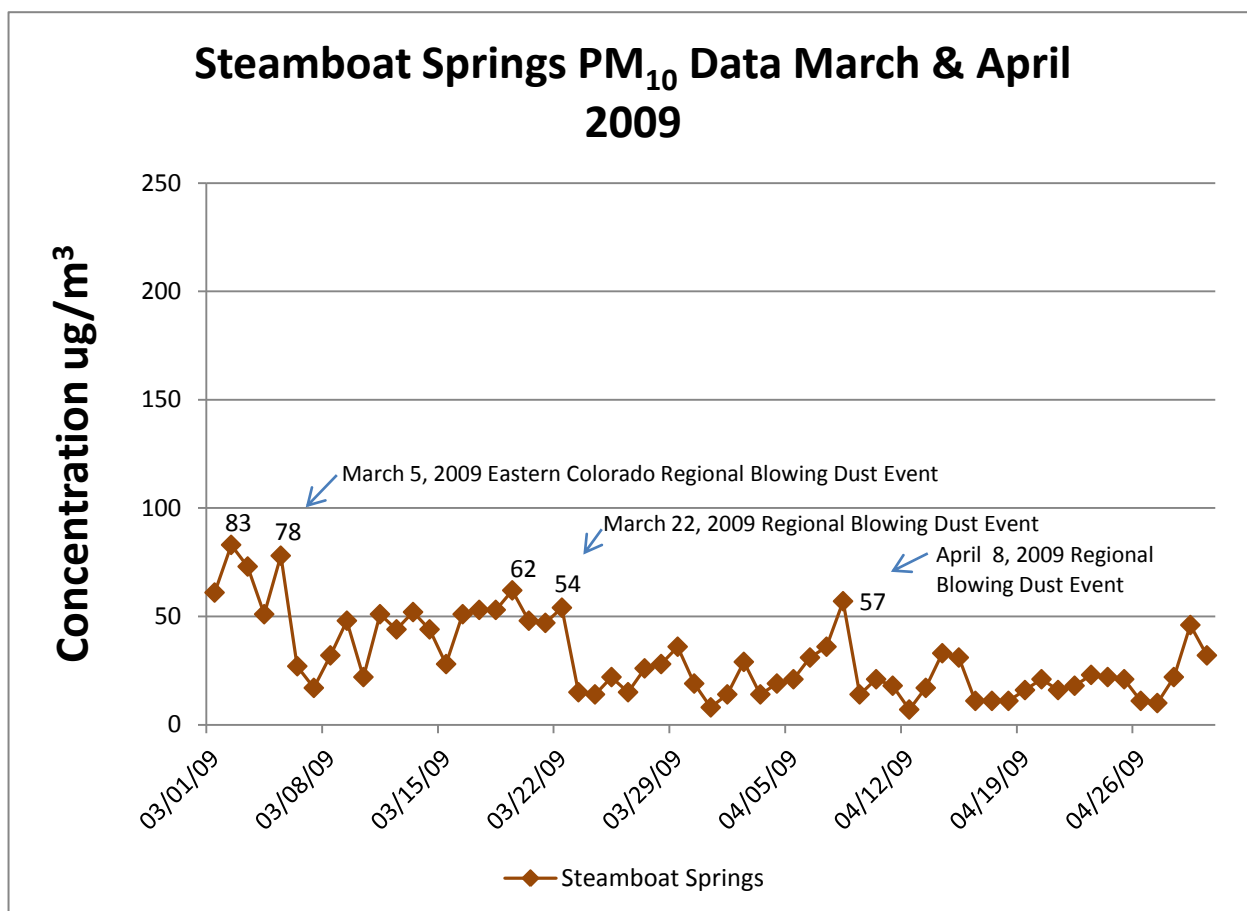


Figure 37. PM₁₀ Seasonal Concentrations in Steamboat Springs, March and April, 2009.

Figures 38 through 40 show all PM₁₀ data for 2009 in Mount Crested Butte, Lamar, and Steamboat Springs, respectively. This data confirms that without a regional blowing dust event PM₁₀ levels do not typically exceed 50 µg/m³ at the mountain locations and about 60 µg/m³ in Lamar. This presents an even more dramatic picture of typical PM₁₀ concentrations in the three areas that are spread far apart and in different topographical regions.

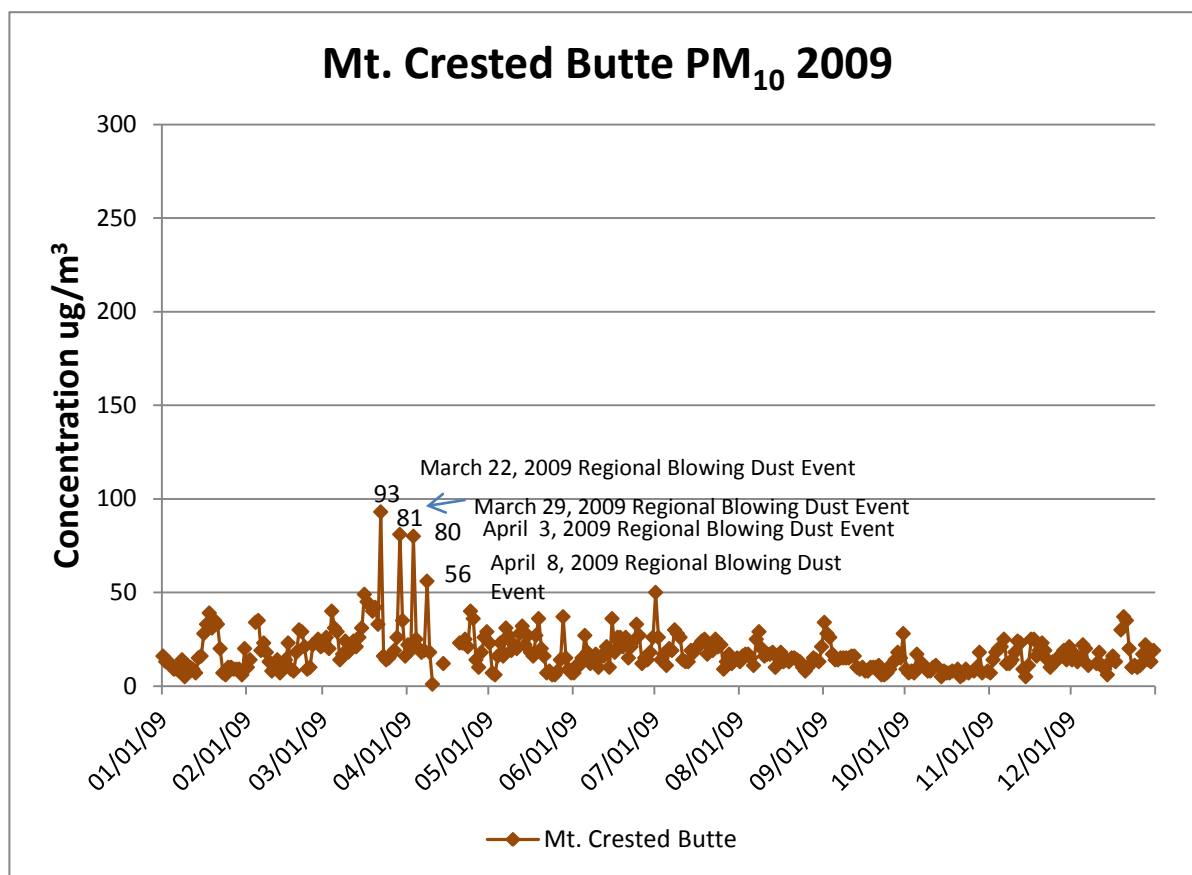


Figure 38. PM₁₀ Annual Concentrations in Mount Crested Butte during 2009.

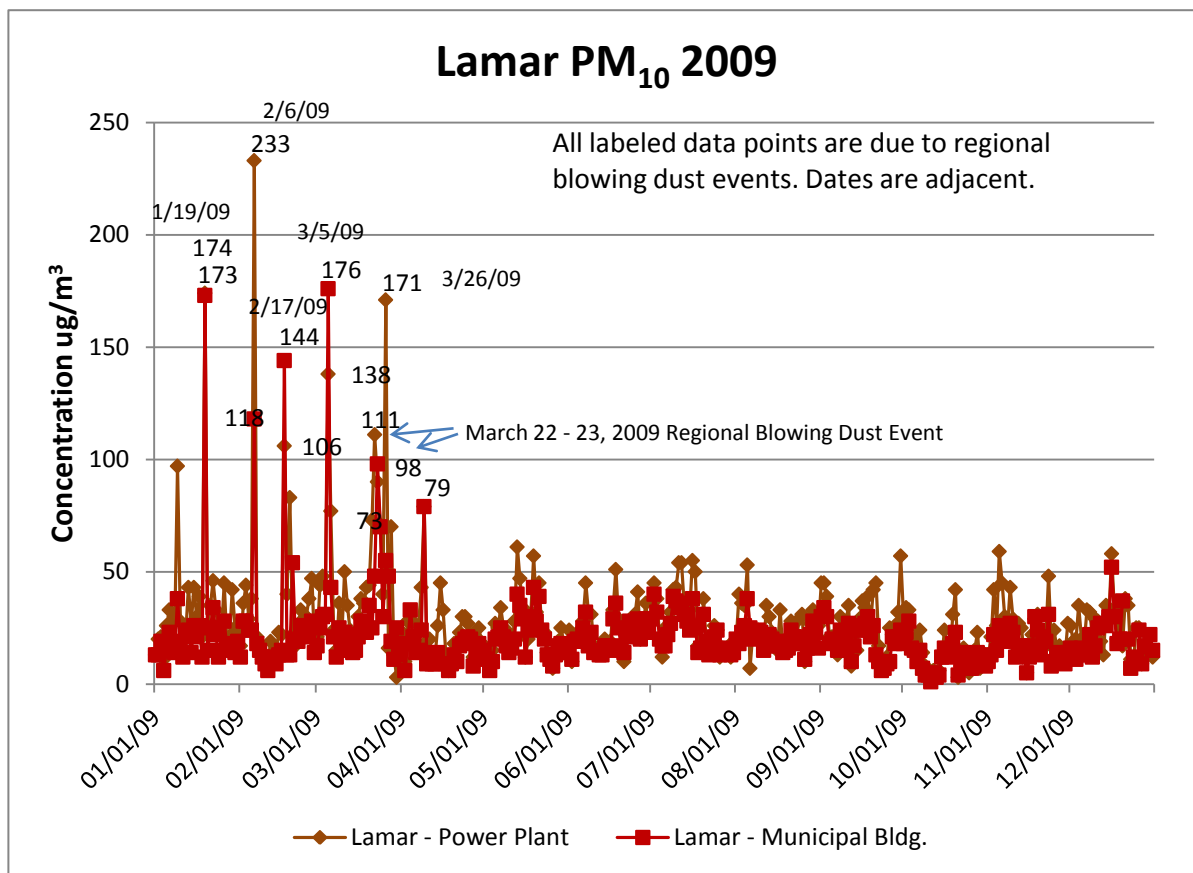


Figure 39. PM₁₀ Annual Concentrations in Lamar during 2009.

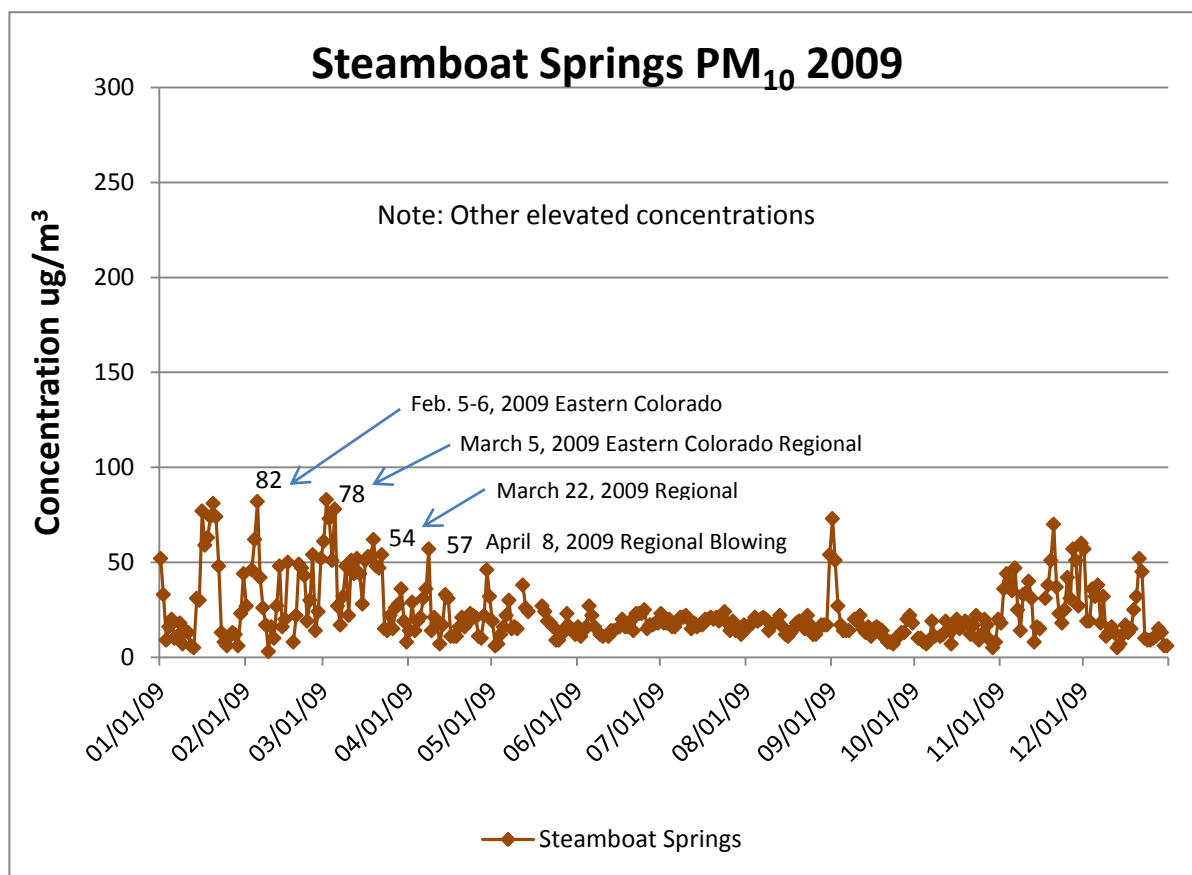


Figure 40. PM₁₀ Annual Concentrations in Steamboat Springs during 2009.

The PM₁₀ monitoring data for 2009 as presented in figures 33, 38, 39, and 40 clearly show that the PM₁₀ exceedance at Pagosa Springs on March 22 and the high concentrations at Mount Crested Butte, Lamar, and Steamboat Springs were unusually high. Also, the 2009 charts show that all exceedances and most PM₁₀ concentrations elevated above approximately 60 µg/m³, with a few minor exceptions, occurred during the January through March time frame. Each of the events identified on the charts above were analyzed by APCD meteorologists and scientists and each has been flagged as being caused by high wind/blowing dust events.

The concentration of 255 µg/m³ at Pagosa Springs was an exceptional event and the available monitoring data from other daily sites supports that the blowing dust event was spatially large covering a most of the southern and central parts of Colorado. The monitoring data on March 22 at Pagosa Springs was much higher than surrounding days and much higher than the entire year. A full statistical analysis of the PM₁₀ monitoring data at Pagosa Springs is presented below. These data will demonstrate just how exceptional March 22, 2009 was and a “but for” test is also presented in section 3.1 below to show that the PM₁₀ exceedance at Pagosa Springs would not have occurred but for this large regional dust storm that was not reasonably controllable or preventable.

Section 3.1 Historical Fluctuations of PM₁₀ Concentrations Pagosa Springs

This historical fluctuation evaluation of PM₁₀ monitoring data for sites affected by the March 22, 2009 event was made using valid samples from PM₁₀ samplers in Pagosa Springs. APCD has monitored PM₁₀ in Pagosa Springs at two different sites (080070001 and 080070002) at various frequencies and intervals

beginning in 1985. However, it's only been since 1992 that monitoring was performed with a consistent frequency (daily) and with sufficient completeness (> 75%) to satisfy data requirements for this analysis. Therefore, the data in this analysis is from both sites in Pagosa Springs beginning January 1992 through the end of 2009. The sites are spatially situated so that concerns regarding comparability between sites is minimal. There was no time period when data was taken at both sites simultaneously; however the data from each set reflect a similar distribution. The overall data summary is presented in Table 12, all data values are presented in $\mu\text{g}/\text{m}^3$:

Table 12. PM₁₀ Monitoring Data Summary for Pagosa Springs.

Summary - Entire Dataset	
	Pagosa Springs
Count	6096
Min	3
1 Q	18
Median	24
3 Q	36
Max	262
Mean	28.6
SD	17.6
Date Range	1992 - 2009
3/22/2009	255

The spatial scope of this event, addressed elsewhere in this document, was statewide and had an impact on PM₁₀ concentrations at multiple sites. However, the 255 $\mu\text{g}/\text{m}^3$ at Pagosa Springs was the only site greater than the 150 $\mu\text{g}/\text{m}^3$ level of the NAAQS and is the only data set discussed in detail. A snapshot of data from those sites affected by the event is presented in Table 13, along with the approximate percentile value that data point represents for each site for their unique historical data sets, for the year of the event, and for the month.

Table 13. PM₁₀ Monitoring Data Percentiles of Frequency for Other Areas with Elevated PM₁₀.

	Mt. Crested Butte	Lamar Power	Steamboat Springs
3/22/2009 ($\mu\text{g}/\text{m}^3$)	93	111	54
Overall	99.6%	99.1%	90.6%
All March	99.8%	98.7%	67.0%
2009	99.8%	98.9%	94.0%

Additionally, the Pagosa Springs data set was summarized by month and year. These summaries (see Figures 41 through 43) present no obvious 'season'; PM₁₀ levels at any particular site in Colorado do not necessarily fluctuate by season. Of greater importance affecting day-to-day, typical PM₁₀ concentrations are local sources, e.g. road sanding and sweeping, local burning from agriculture and residential heating, vehicle contributions via re-entrained road dust from paved and unpaved roads, track-out from unpaved lots, etc. While the historic monthly median values for Pagosa Springs are higher during the winter and spring months than the rest of the year there is little month-to-month variation. This time frame (winter and early spring) is that which is most likely to experience the meteorological and dry conditions exhibited during this event and discussed in section 2.0 of this document. The lack of variability between

monthly medians suggests that typical data exhibiting regular variation are those in the inner-quartile range (i.e. between the 75th and 25th percentile). If a conservative approach is taken then a typical value should be no higher than the historic monthly 75th percentile value. The summary data for the month of March (all samples in any March) and for 2009 is presented in Table 14, in $\mu\text{g}/\text{m}^3$:

Table 14. Pagosa Springs Month and Year PM₁₀ Monitoring Data Summary.

	March (1992-2009)	2009
Count	524	354
Min	5	6
1 Q	20	16
Median	31	20
3 Q	44	26
Max	255	255
Mean	35.8	24.9
sd	23.1	23.4

Pagosa Springs – 080070001 and 080070002

The PM₁₀ sample on March 22, 2009 at Pagosa Springs of 255 $\mu\text{g}/\text{m}^3$ exceeds the 99th percentile value (107 $\mu\text{g}/\text{m}^3$) for all March data, exceeds the 99th percentile value (138 $\mu\text{g}/\text{m}^3$) for all 2009 data, and exceeds the 99th percentile value (56 $\mu\text{g}/\text{m}^3$) for the entire dataset. Overall, this sample is the third highest sample in the entire data set, the highest sample in 2009, the maximum sample in any March, and exceeds the 99th percentile sample value for this site for all samples. The two samples in the entire data set greater than the event sample are 262 $\mu\text{g}/\text{m}^3$ (12/29/94) and 262 $\mu\text{g}/\text{m}^3$ (12/21/1994); both samples are associated with high wind events. There are 6096 samples in this dataset. The sample of March 22, 2009 clearly exceeds the typical samples for this site. This more than adequately, demonstrates that the high wind blowing dust event certainly affected air quality on March 22, 2009.

Figures 41 through 43 graphically characterize the Pagosa Springs PM₁₀ data. The first plot is the overall frequency histogram. The histogram displays a well-formed density function, almost 80% of the samples values are less than 40 $\mu\text{g}/\text{m}^3$ and over 90% of the samples are less than 50 $\mu\text{g}/\text{m}^3$.

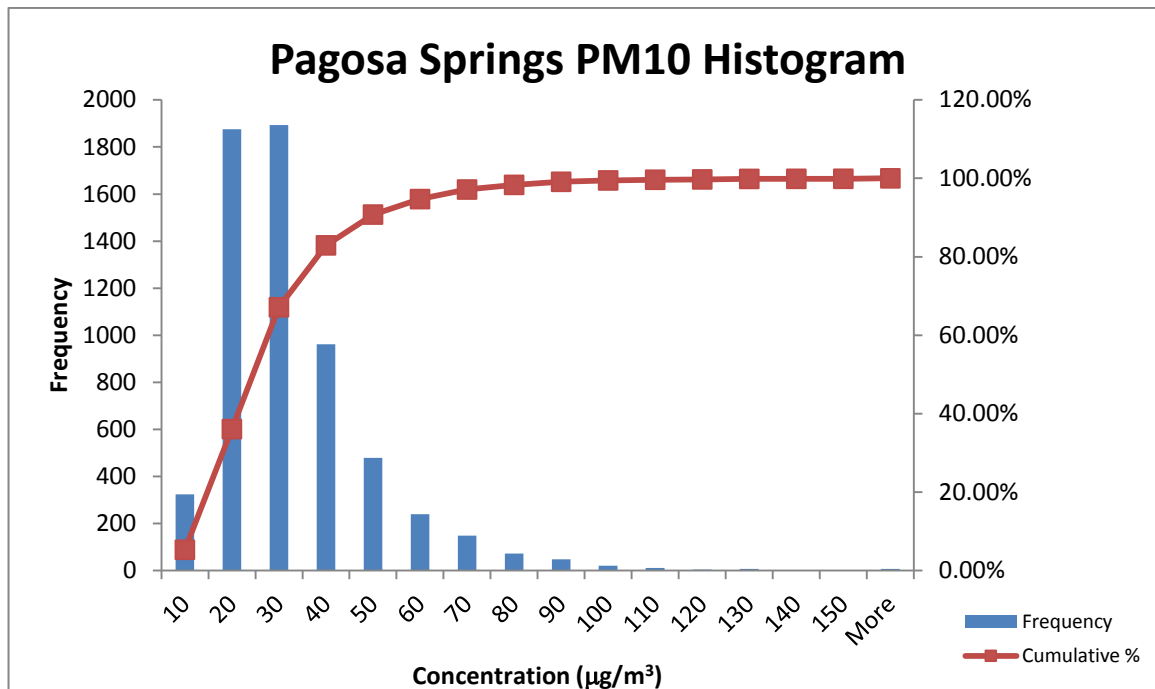


Figure 41. Pagosa Springs PM₁₀ Histogram.

The monthly box-whisker plot in Figure 42 highlights the consistency of the majority of data from month to month. Note the greater variability (wider inner-quartile range) and greater range of the data through the winter and early spring months that's accompanied by typically greater monthly maxima. Recall, this time period experiences a greater number of days with meteorological conditions similar to those experienced on March 22, 2009. Although these high values affect the variability and central tendency of the dataset they aren't representative of what is typical at the site.

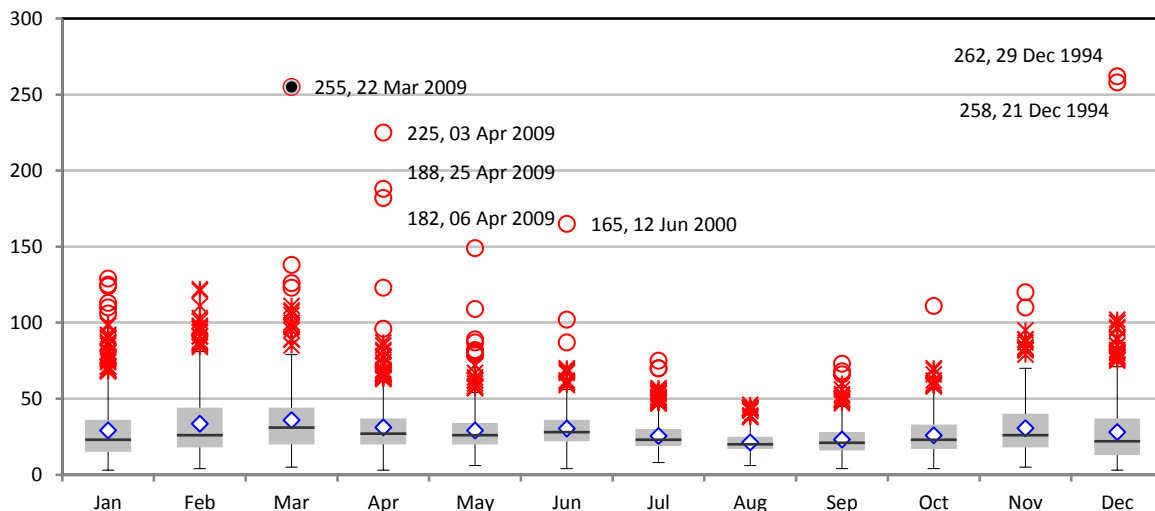
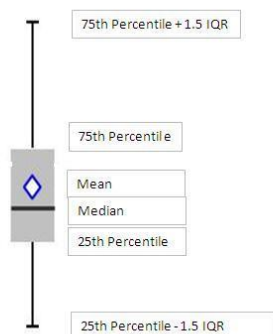


Figure 42. Monthly Pagosa Springs PM₁₀ Box and Whisker Plot.

All the box plot features in this evaluation can be identified with the following legend:



Where:

1Q is the 25th percentile,

3Q is the 75th percentile value and

IQR is the interquartile range or the range of the middle 50% of a distribution (75th percentile value – 25th percentile value).

Additionally there are two types of outliers identified in these plots: outliers greater than $3Q + 1.5 \times IQR$ and outliers greater than $3Q + 3 \times IQR$. The outliers that satisfy the last criteria are labeled with sample value and sample date for those samples greater than $150 \mu\text{g}/\text{m}^3$. Each of these outliers is associated with a known high-wind event similar to that of March 22, 2009. One sample, April 6, 2009, is believed to have been mislabeled by the operator and the sample actually was taken on the April 8, 2009 – corresponding to another high wind event.

The box plot of annual summaries may point to a trend of decreasing sample values, but without a similar decrease in the number of outliers. In 2009 there were more samples greater than $150 \mu\text{g}/\text{m}^3$ than in any other year yet the variation in the data as measured by the IQR is less than that for any year except 2006. Each of these samples from 2009 is associated with an event similar to the one discussed here.

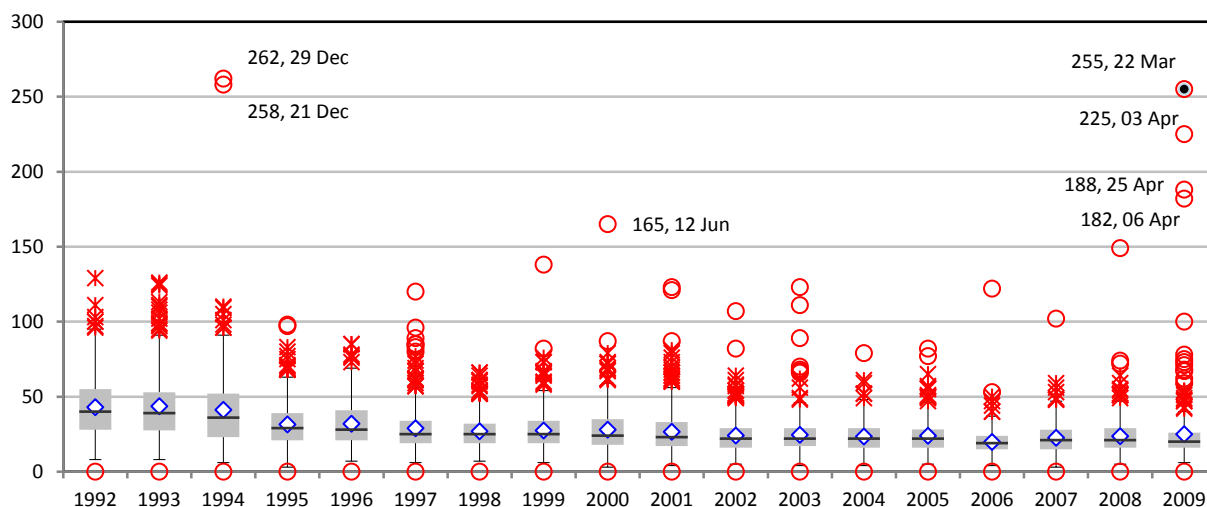


Figure 43. Annual Pagosa Springs PM₁₀ Box and Whisker Plot.

No Exceedance But For the Event

An estimation of PM₁₀ due to the event is presented here. Based on the entirety of data in the Historical Summary (including multiple high wind events), a conservative estimate of the ‘typical’ values in March for Pagosa Springs would have been between 44 and 56 µg/m³ corresponding to the 75th and 84th Percentile values. Using these conservative values as ‘typical’ would indicate that the event provided an additional 199 – 211 µg/m³ contribution from the 22-March event. Clearly, the sample from March 22, 2009 exceeds what is typical for this site and “but for” this large regional blowing dust storm Pagosa Springs would not have exceeded the 24-hour PM₁₀ NAAQS.

						Est. Conc. Above Typical (µg/m ³)
Site	Event Day Concentration (µg/m ³)	March Median (µg/m ³)	March Average (µg/m ³)	March 75 th % (µg/m ³)	March 84 th % (µg/m ³)	
Pagosa Springs	255	31	35.8	44	56	199 - 211

Table 15. Estimation of event PM₁₀ totals for Pagosa Springs.

Section 3.2 Monitoring Data and Conclusions

Since the local anthropogenic sources are well controlled in Pagosa Springs and the surrounding area is covered by trees and other vegetation, and since the sustained surface wind speeds were well above 25 mph in the region of the dust storm, it follows that the dust was transported into Pagosa Springs on March 22, 2009. This high wind blowing dust event affected the air quality in Pagosa Springs and several other locations, including but not limited to Mount Crested Butte, Lamar, and Steamboat Springs, and Aspen (qualitatively) in the state of Colorado on March 22 and 23, 2009. The size and extent of the blowing dust storm made the event not preventable and it could not be reasonably controlled. Statistical data in section 3.1 above clearly shows that but for this high wind blowing dust event Pagosa Springs would not have exceeded the 24-hour NAAQS on March 22, 2009.

4.0 News Accounts and Credible Evidence

Figure 44 is a copy of an email from Lee Cassin the Environmental Manager for Pitkin County Colorado. The email talks about “brown snow”. This snow was brown or reddish brown due to the dust that was lifted into the atmosphere in Arizona and New Mexico and then transported to the Aspen Colorado area by the same storm already described above. The dust was lifted over the frontal boundary where it was entrained into clouds associated with the dynamics of the storm. The dust was then scavenged by snow in the clouds and deposited on the ground with the rain and or snow that reached the ground. Figure 44 a. is an internal email discussing Cassin’s query. Figure 45 is a similar notice from the Mt. Crested Butte Town Manager.

Figures 46, 47, and 48 are pictures of dust on cars in Aspen from the snow that Lee Cassin talks about. Figures 49, 50, and 51 are local news stories about the event.

Figure 52 is the modeled snow depth for March 23, 2009, at 00Z (March 22, 5PM) in the Aspen area – for just prior to the onset of the evening rain/snow event in Aspen on March 22, 2009. It shows that, except for the valley running to the northwest from Aspen, the area was snow covered. This demonstrates that the dust in Lee Cassin’s pictures did not come from the local area but was transported into the area with the strong southwesterly winds and transport regime already described in detail in this report. Since Aspen is 130 miles to the north of Pagosa Springs, the air mass with the suspended dust would have had to pass over the Pagosa Springs area before reaching Aspen.

Figure 53 is a climatology paper describing factors relating to the event.

From: "Lee Cassin" <Lee.Cassin@ci.aspen.co.us>
To: <ecmalone@cdphe.state.co.us>
Date: 3/23/2009 11:59 AM
Subject: natural dust event

Emmett,

This is just to let you know that last night we had a very unusual weather event, and our office has been getting calls from citizens and the media. We had winds the last couple of days (Sat. and Sun.), though not extremely strong. Last night around 8 or so, it started raining and then snowing, or rain mixed with snow. The next morning there was "brown snow" everywhere. It looked like snowplows had coated everything with brown road slush and sand. After the initial event, there was normal snow, but the first frozen rain/snow was completely brown. I remember a March event several years ago that created a lot of red dust, but this was different in that it was brown, not red and happened at the beginning of a snowstorm.

It might be interesting to look at the cocorahs network and see how many reports there were.

Lee

Figure 44. March 23, 2009, email from Lee Cassin, the Environmental Manager for Pitkin County, Colorado.

From: GORDON Pierce
To: Malone, Emmett; McGraw, PAT
CC: Briggs, Kevin; Machovec, CHUCK; Reddy, Patrick
Date: 3/23/2009 12:11 PM
Subject: Re: Fwd: natural dust event

Three items that I see in the CoCoRaHS comments for this morning:

3/23/2009 CO-DL-8 Hotchkiss 9.0 WNW excellent dust storm yesterday afternoon, visibility down to about 1 mile for a while. precipitation began as rain.

3/23/2009 CO-EG-8 Wolcott 2.3 N High 62°F, Low 30°F, 7am 30°F; Cloud cover - 100% 4 miles visibility in very light drizzle; Last night about 11pm light snow fall and rain was very very dirty; leaving brown stain on shirt and cars.

3/23/2009 CO-EG-21 Vail 0.9 WNW It is snowing hard at 7 am. The snow washed a lot of dirt out of the air. The collection samples were very dirty.

Gordon

>>> Emmett Malone 3/23/2009 12:02 PM >>>
Thought you might like to see this.

Emmett

>>> "Lee Cassin" <Lee.Cassin@ci.aspen.co.us> 3/23/2009 11:58 AM >>>
Emmett,

This is just to let you know that last night we had a very unusual weather event, and our office has been getting calls from citizens and the media. We had winds the last couple of days (Sat. and Sun.), though not extremely strong. Last night around 8 or so, it started raining and then snowing, or rain mixed with snow. The next morning there was "brown snow" everywhere. It looked like snowplows had coated everything with brown road slush and sand. After the initial event, there was normal snow, but the first frozen rain/snow was completely brown. I remember a March event several years ago that created a lot of red dust, but this was different in that it was brown, not red and happened at the beginning of a snowstorm.

It might be interesting to look at the cocorahs network and see how many reports there were.

Lee

Figure 44 a. Response to Cassin email.

From: "Joe Fitzpatrick" <JFitzpatrick@mtcrestedbutte-co.gov>
To: "RAY Mohr" <rmohr@smtpgate.dphe.state.co.us>
Date: 3/26/2009 11:04 AM
Subject: Mt. Crested Butte Wind Event

Hi Ray,

I trust you are doing well. We are in the middle of a great March Spring Snow Storm, 12 inches and still snowing!

On March 22 and March 23, 2009 Mt. Crested Butte and Gunnison County experienced a major wind event with the front edge of this snow storm that blew a large amount of the red dust in from the desert. So we had red dust ahead of and mixed with our snow last Monday morning. Thus the monitors should have picked up a lot of red desert dust and I just wanted you to make a note in your logs because it would be great to see if there is a major spike in your dust readings.

Have a great day!

Thanks,

Joe

Joseph W. Fitzpatrick, Jr.
Town Manager
P.O. Box 5800
Mt. Crested Butte, Colorado 81225
U.S.A.

970-349-6632
fax: 970-349-6326
www.mtcrestedbuttecolorado.us

Figure 45. Mt. Crested Butte Town Manager description of the event.



Figure 46. Dust on vehicle in Aspen, Colorado, after the March 22, 2009 dust storm, from Lee Cassin, the Environmental Manager for Pitkin County, Colorado.



Figure 47. Dust on snow in Aspen, Colorado, after the March 22, 2009 dust storm, from Lee Cassin, the Environmental Manager for Pitkin County, Colorado.



Figure 48. Dust on vehicle in Aspen, Colorado, after the March 22, 2009 dust storm, from Lee Cassin, the Environmental Manager for Pitkin County, Colorado.

Aspen still waiting for big snow

Aspen Times Staff Report
Aspen, CO Colorado

ARTICLE
COMMENTS

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A robin, harbinger of spring, watches as winter returns to downtown Aspen Monday.

Janet Urquhart / The Aspen Times

ASPEN — A winter storm warning for parts of the Colorado Rockies, including the Aspen area, has been extended to 6 a.m. Tuesday, but only a few inches of new snow had materialized on local ski slopes by Monday morning.

The National Weather Service continues to call for heavy snow in the Colorado mountains, and rain or rain mixed with snow in the valleys, along with strong winds at higher altitudes that will result in blowing and drifting snow. Eight to 16 inches of new snow are possible by Tuesday morning, according to the weather service.

The storm warning was initially set to expire Monday at 6 p.m., but it has been extended to early Tuesday, as snow is now expected to continue through Monday night, the weather service said.

High winds ushered in the weather system on Sunday, stirring up dust out of the Southwest that coated Aspen ski slopes with a layer of brown grit. The brown was visible where ever ski tracks cut through the snowy overcoat early Monday and where grooming machines churned up the snow.

Aspen Mountain reported 4 inches of new snow on Monday morning; Highlands, Buttermilk and Snowmass all reported 3 inches. Most resorts around the state were reporting from 2 to 5 inches of new snow.

For Aspen, the weather service is predicting 4 to 7 inches on Monday, another 2 to 4 inches Monday night and a 60 percent chance of snow Tuesday with accumulations of about 1 inch. Highs of 25 to 35 are expected Monday and Tuesday, along with west winds of 10 to 15 mph both days.

Wednesday's forecast calls for a 40 percent chance of snow and highs in the 30s. Moderate snow accumulations are forecast on Wednesday night, and snow is likely Thursday with highs in the 20s, according to the weather service. Snow remains in the forecast Thursday night and Friday.

Figure 49. Aspen Times staff report.

What's with the brown snow?

[Send us your news](#)

Tuesday, April 7, 2009

Chris Outcalt
Vail Daily

[Email Print](#)



Minturn resident John Knight took this picture of the Vail Valley's peculiar snow at his home Saturday
Special to the Daily / John Knight

[ENLARGE](#)

The rust-tinged snow scattered around the Colorado mountains this past weekend had nothing to do with a volcano in Alaska, according to the National Weather Service.

The state's ski slopes were covered with dirty-looking snow on Saturday. And Chris Cuoco, a forecaster with the weather service in Grand Junction, said the rumors that the snow had ash from Southern Alaska's Mount Redoubt — which has erupted several times recently — in it are false.

"We heard that a lot, It's definitely not," Cuoco said. "That volcano didn't produce anywhere near the ash necessary."

Mount Redoubt is 100 miles southwest of Anchorage and tends to erupt every decade or so, belching ash for months. Geologists have recorded at least 19 eruptions since March 22, including one on Saturday.

But the weekend storm that hit the valley picked up dust from Arizona, Utah and western Colorado, giving it a rust color, Cuoco said.

"A lot of dirt and dust was carried into the atmosphere and suspended in it," Cuoco said. "The snow and rain washed out a good portion of it out and you end up with pink snow falling."

A similar storm hit the high country at the end of March.

"There was a decent content of red dust down by the Four Corners," he said.

It's not unusual for a dirt-filled storm to hit the valley this time of year, Cuoco said.

"In the spring and fall the jet stream is directly over us and the storms that move through usually have a lot of wind," he said. "It sets up just right, with the very strong winds and dry conditions ahead of (the storm)."

It is possible for volcanic ash from west of the state to make its way to Colorado, but the eruption would have to be a lot bigger and the winds would have to be just right, Cuoco said.

The Associated Press contributed to this report.

Figure 50. Vail Daily news article.

Dust storms turn Aspen slopes brown Monday, March 23, 2009

Janet Urquhart
The Aspen Times
Aspen, CO Colorado

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The lower slopes of Aspen Highlands take on a brownish hue Monday morning, the result of dust storms elsewhere.

Janet Urquhart / The Aspen Times

ASPEN — Despite a few inches of fresh snow Monday morning, Aspen's ski slopes sported an uncharacteristic brown hue, thanks to blustery winds carrying dirt from the Southwest and, perhaps, China.

Elsewhere in the Roaring Fork Valley, residents awoke to a spotty layer of dirt on their vehicles, thanks to precipitation that pulled the particles out of the air.

"When I looked at my car and my outdoor furniture, I thought, 'Wow, we had brown snow,'" said Jeff Hanle, Aspen Skiing Co. spokesman. "We're just thankful that it's snow."

Dirt was deposited on the ski slopes and then covered over by the 3 to 4 inches that fell in Aspen and Snowmass on Sunday night. But, where snowcats churned up the surface, the dirt reappeared, giving groomers a brownish cast early Monday. Wherever skiers carved through the surface layer of white snow on ungroomed runs, brown appeared in their tracks. By afternoon, the bump runs on Aspen Mountain had a leopard-print look about them.

It's not the first time strong spring winds have carried dirt from elsewhere.

"We ended up with red snow one time," Hanle recalled. "It all came from Utah."

The dirt swirling in the air on Sunday wasn't local, either, according to Lee Cassin, environmental health director for the city of Aspen. Rather, the slopes were sporting grit from the desert Southwest, and possibly from as far away as China, where a huge plume of dust from a Gobi Desert sandstorm more than a week ago was carried aloft, she said.

It's not the first time sand from China has drifted around the globe and been pulled from the atmosphere with precipitation in Aspen, Cassin noted.

Closer to Colorado, wind-whipped dust storms in Utah, New Mexico and Arizona were undoubtedly a factor, as well, she said. In Colorado, Montrose and Cortez reported visibility of less than a mile on Sunday. In Grand Junction, wind gusts of up to 60 mph were recorded.

The winds came in advance of a winter storm that is expected to leave 8 to 16 inches of new snow in the Colorado mountains by Tuesday morning, when a winter storm warning is to expire at 6 a.m. By midafternoon Monday, little of the predicted snow had fallen in Aspen, but the National Weather Service was continuing to call for significant snowfall.

janet@aspentimes.com

Figure 51. Aspen Times dust article.

Climatology of Spring 2009/2010 Dust Storm Events Across the Little Colorado River Valley of Northeastern Arizona

June 2011

Chris Outler, NWSFO Flagstaff AZ

Nick Petro, NWSFO Flagstaff AZ

Jeremy Mazon, ERAU

Doug Lotter, ERAU

Abstract

High impact blowing dust events frequent the Little Colorado River Valley (LCR) in northeast Arizona during periods of high winds often observed during the spring months. This study examined several cases of observed blowing dust while comparing them against each other, in addition to evaluating the peak wind speeds observed for each event. Further analysis into both short and long term drought conditions and their influence on dust severity was considered as well. The study found that wind advisory criteria being met across the LCR usually led to minimal disruptions to travel with limited blowing dust observed, while high wind warnings often led to significant travel disruptions and areas of widespread blowing dust. Drought severity appeared to play a role in blowing dust, though a conclusive relationship is difficult to attain given lack of dust storm history in this area. The approximate threshold for dust suspension is presented which will aid forecasters in anticipating future high impact dust events in northeast Arizona.

Introduction

During the spring months of 2009 and 2010, numerous significant wind storms impacted parts of northern Arizona, but the largest impact was not from the wind itself, but rather from dust being blown by the wind. The blowing dust lead to localized, but significant reductions in visibility, enough to close sections of Interstate 40 numerous times over the course of the spring. Additionally, some of these dust events were extended in nature, one closing the interstate for two days, all due to a limited sector of roadway being impacted by heavy blowing dust.

Given the fact that these storms usually occur in advance of a large scale synoptic system, they are extremely predictable when strong winds are forecast in this region. Proper forecasting of future dust episodes is essential to improve our decision support efforts during these high impact weather events.

Figure 53. Little Colorado River climatology paper.

This study aims to improve prediction of future dust storms in the Little Colorado River Valley and greater northeast Arizona by examining the source region of the dust, the geographic area affected; wind speed thresholds necessary to create blowing and suspended dust, as well as the synoptic conditions associated with the dust storm events. The study also considers how short and long term precipitation deficits may have contributed to the severity of the dust storms.

Background

The Little Colorado River Valley (LCR) is a sparsely populated region which covers a broad section of northeastern Arizona (Appendix 1, Figure A-1). This region features arid to semi-arid climatology with the elevations ranging from 4,000 to 6,000 feet, and a vegetation type consisting of sparse vegetation with dry and loose soils. Most susceptible to dust suspension are dry river and lake beds frequently present in the Little Colorado River drainage region, which may act as source region for significant blowing dust (ADEQ, 2009). When winds become strong, this loose soil can be easily blown by the wind and suspended through a deep layer of the lower troposphere as was the case on numerous dust events during the 2009/2010 spring seasons. Additionally, Interstate 40 runs from east to west along the center portion of the LCR, making it highly susceptible to blowing dust.

During the spring months of 2009, and especially 2010, drought conditions expanded across the already dry LCR, with the US Drought monitor expanding D1/D2 (Moderate/Severe) drought status into parts of northeastern Arizona. This may have compounded with the frequent wind events in the spring to intensify the severity of blowing dust. A study from the National Weather Service (NWS) El Paso Weather Forecast Office (WFO) found a 95% correlation with severe blowing dust days and years with below normal precipitation (Novlan et. al, 2006), further supporting the likely role ongoing drought plays on regional dust events. The springs of 2009 and 2010 were also the first in recent memory of any interstate closures being caused by blowing dust, leading to questions of changes in land use in addition to the ongoing drought.

The Arizona Department of Transportation (ADOT) has examined the soil types and biomes from which the blowing dust has originated. Figure 1 illustrates the blowing dust areas overlaid with specific land types from which the dust is originating. The biome type is considered Great Basin desert scrub within the semi-arid land type, which tends to accumulate dust and salts, and is mostly devoid of heavy land cover or grasses (ADOT 2009). The greatest dust suspension is located immediately downwind of the Little Colorado River drainage, where dry river and lake beds create an optimal environment for dust lofting due to the presence of fine soils. This land type, especially after a period of dryness or when the riverbed dries out, favors blowing dust when winds become strong enough to suspend the dust particles.

(Figure 53, continued)

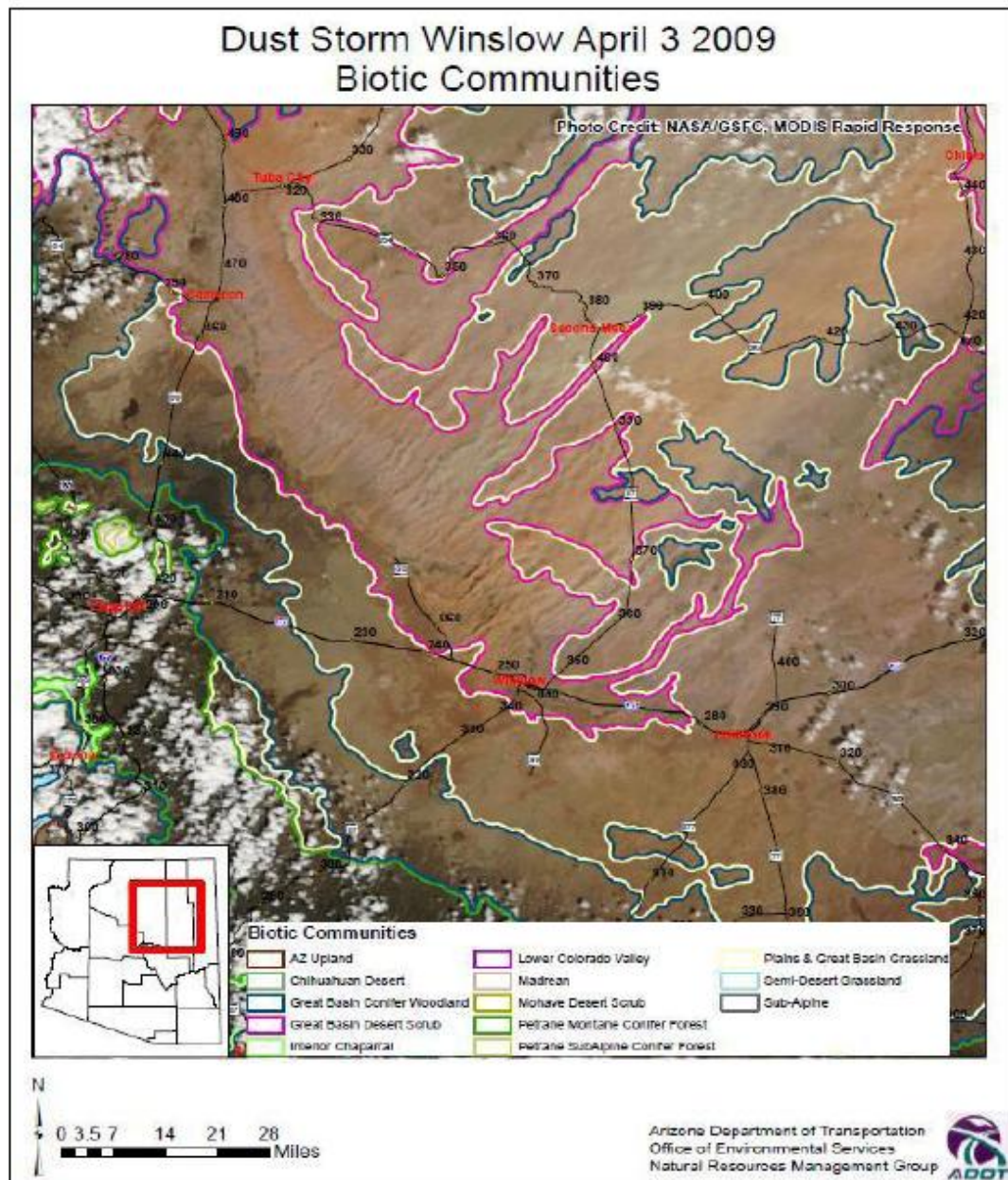


Figure 1 Biotic communities overlaid with blowing dust from April 3rd, 2009 dust event.

As is typical in high impact weather events, the dust storms caught a fair amount of local media attention, listed below are a few excerpts from local newspapers about the storms:

(Figure 53, continued)

"A blizzard of dust powered by 74 mph wind gusts resulted in zero visibility and forced the closure of an 8-mile section of Interstate 40 west of Winslow for about 12 hours Wednesday. Conditions were severe over a 30-mile stretch of highway -- four times the usual area affected." (Arizona Daily Sun 4/29/10)

"Strong winds and blowing dust have closed stretch the stretch of Interstate 40 between Meteor Crater rest area and Winslow for the second time in less than a week." (Arizona Daily Sun 4/12/10)

"The fourth dust storm in a month stopped Interstate 40 traffic east of Flagstaff for more than six hours Wednesday." (Arizona Daily Sun 4/15/09)

The impacts of the dust storms were not limited to motorists on I-40. At least one storm led to the early dismissal of a school in Leupp, located in the Navajo Nation, because driving winds and blowing dust created "red-out" conditions.

Methodology

The study began by examining archives of NWS text products, primarily wind advisories and high wind warnings that were issued during March, April, and May from 2009 through 2011. These products provided a foundation for the dates which needed to be examined more closely as possible dust event cases. A search was also performed of archived newspaper articles relating to highway closures during the same time frame. The majority of newspaper articles came from the Arizona Daily Sun, a major Flagstaff newspaper. A detailed listing of specific mileposts and times of the regional closures was also provided by ADOT, which significantly aided in knowledge of specific location and timing of the worst visibility reductions (Appendix 1, Table A-1).

Once the dates of the dust storms had been determined, archived surface observations were obtained through MesoWest. The surface observations provided information on wind speed, winds gusts, wind direction, and visibility. Statistical relationships between wind speeds and visibility reduction were also examined using weather data from the ADOT sensor at Two Guns, and the Winslow, AZ Automatic Surface Observing System (ASOS). Unfortunately, observing sites are quite sparse in the LCR, so the satellite information was a necessity to have a complete set of data.

Visible satellite imagery, obtained through National Oceanic and Atmospheric Administration (NOAA) archives, was then examined to determine what time and location the dust began and detailed which areas were affected by the dust. The satellite imagery from all of the dust events was then compiled to depict which areas are most prone to the dust events. With the dust prone areas outlined by the satellite composite overlay, the relationship between wind speed and visibility can be determined.

(Figure 53, continued)

Analysis

This section highlights a few select cases in which the dust was especially prolific across northeast Arizona, to better highlight the significance and location of the problem spots. Thereafter, the statistical relationships between wind speeds, drought conditions, and blowing dust are discussed.

April 3rd, 2009

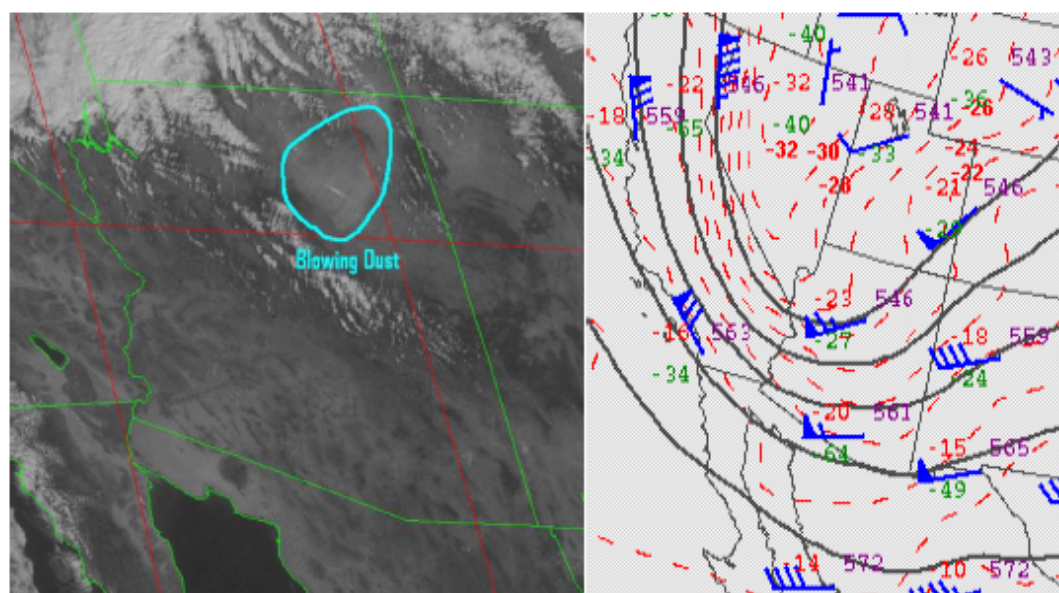


Figure 2- 1715 UTC visible satellite imagery (left), and 00Z April 4th 500 mb analysis (right) depicting strong southwest flow ahead of approaching shortwave trough.

On April 3rd, 2009 a strong trough of low pressure was digging south across the southwestern deserts. This induced a tight pressure gradient across the state of Arizona with a strong southwesterly flow observed across the LCR. The visible satellite image shown in Figure 2, valid at 1715 UTC, indicated a large area of blowing dust across the region downstream of the Mogollon Rim, impacting a broad stretch of the LCR as well as much of Interstate 40. The 500mb analysis for the same day (upper right), indicates a strong shortwave trough approaching northern Arizona. Strong jet stream winds in excess of 60 kts near 500 mb mixed down to the surface in advance of sharp height falls. On this day, peak winds observed in Winslow and Two Guns, both locations frequently impacted by strong winds and blowing dust, were 66 mph and 69 mph respectively. Interstate 40's closure was forced on this day by both the high winds and blowing dust.

(Figure 53, continued)

April 15th, 2009

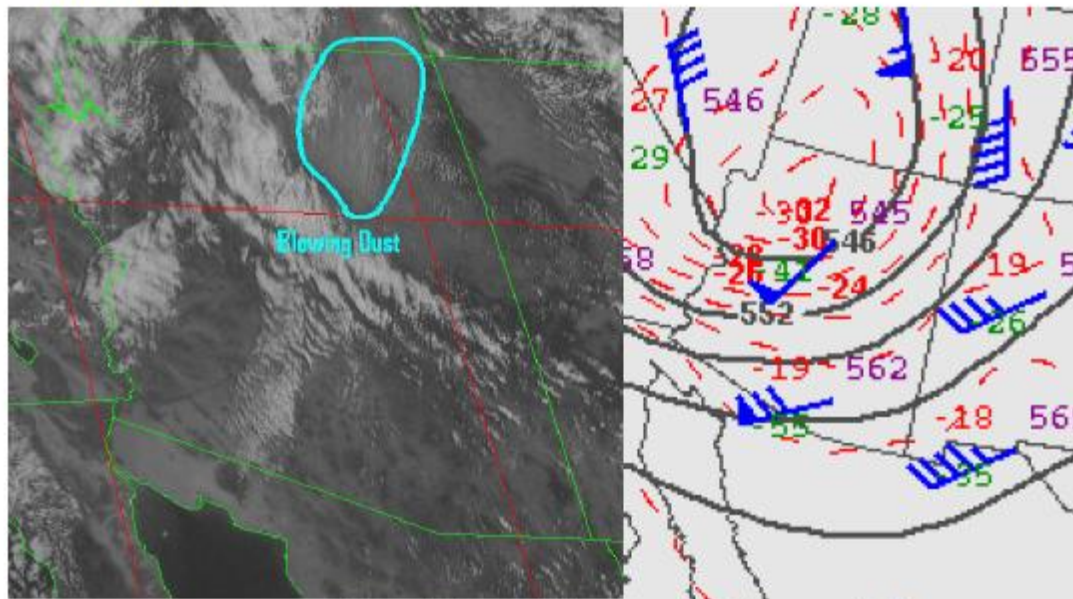


Figure 3 – 1900 UTC visible satellite imagery (left), and 500 mb analysis for 00Z April 16th.

Figure 3 shows that a closed low was lifting across southern Nevada with significant height falls moving across northeast Arizona. Though the setup was different than the week prior, the result was the same. Strong winds stretched across a broad region of the LCR inducing blowing dust from the northern edge of the Mogollon Rim all the way to the four corners. Peak wind speeds of 60 to 70 mph easily suspended dust across the region and reduced visibilities enough to force the closure of Interstate 40 once again.

May 29, 2010

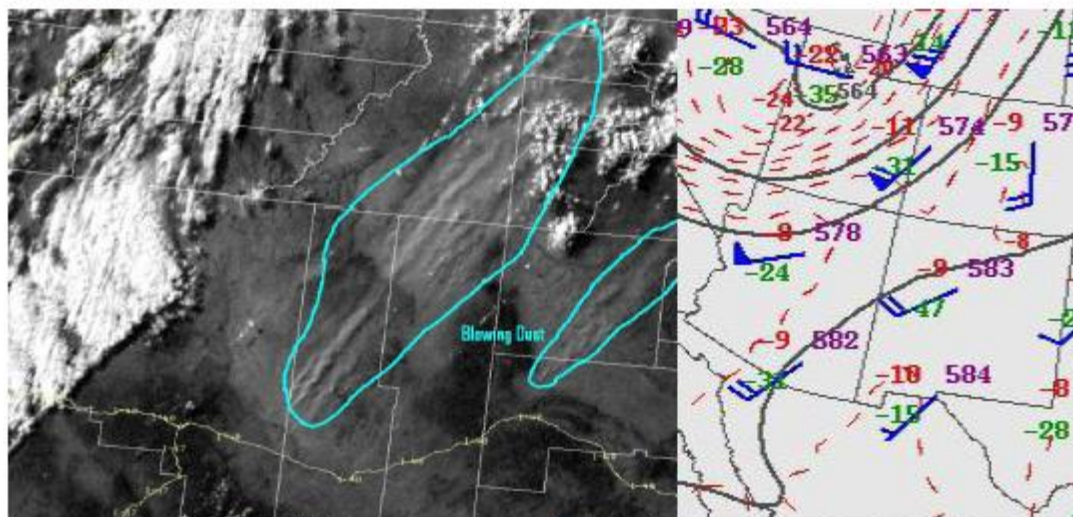


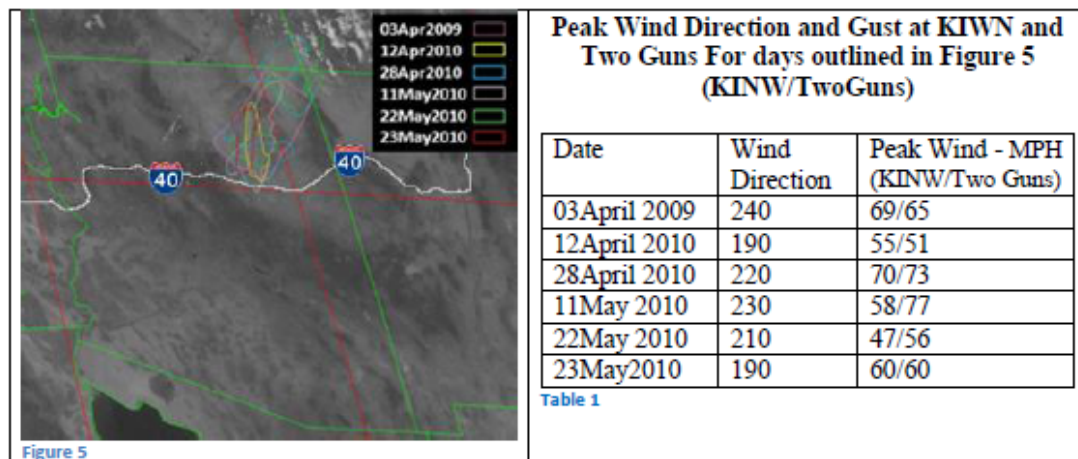
Figure 4 – Visible satellite imagery from 00Z May 30th (left) and corresponding 500mb analysis (right)

(Figure 53, continued)

Figure 4 shows that on May 29th, 2010, a shortwave trough was lifting across the Intermountain West while dragging a cold front across northwest Arizona. In advance of this front, strong winds impacted much of the LCR and four corners region. One notable difference in this case is that the primary dust plumes are concentrated further north, and also north of Interstate 40, closer to the location of the stronger winds with this more northerly shortwave, as illustrated in figure 4. Winds were strong across the southern half of the LCR as well but perhaps not enough to cause windspeed dust concerns, as Winslow's peak wind gust was only 38 mph. The interstate was able to maintain functionality for the duration of the event.

A statistical review of the wind speeds observed in all the dust cases revealed that the average peak wind speed in Winslow and Two Guns was 49 mph, while the average peak wind observed during strictly interstate closing events was 60 mph. More generally, most sub freeway closing wind events consisted of peak winds in the 35-55 mph range, while most freeway closing events consisted of winds gusts of 55mph and above. This relationship indicates most wind advisory days will not observe significant visibility reductions, while interstate closures become more likely once high wind warning criteria is met (Appendix 1, Table A-2).

A composite image of the location and trajectories of the dust plumes was created by overlaying some of the dust plume imagery available (for clear days only), which resulted in the image shown in Figure 5. Table 1 shows the average wind direction and peak wind speed in miles per hour on the days included in the composite shown in Figure 5.



As depicted in Figure 5, blowing dust most frequently develops in the LCR near Winslow while being blown northeastward towards the four corners. There is also a remarkable relationship between the location of the Little Colorado riverbed and the downstream dust plume, signaling the likelihood of the dry river and lakebeds of the Little Colorado as a significant source region for dust suspension. The sparse nature of the data network in far northeast Arizona prevents

(Figure 53, continued)

better observations from being recorded. However, it's likely that areas downstream of the dust plume origin northeast of Winslow, extending all the way to the four corners region, experience even worse reductions in visibility with a greater frequency than what is observed in Winslow and along Interstate 40.

For the six days included in Figure 5, it is noted that on four of the days the primary wind direction was from 210-240 degrees and consequently the dust plume traveled to the northeast and likely impacted the communities of Second Mesa, Keams Canyon, Dilkon, Ganado, Chinle, Many Farms, Canyon De Chelly, Tsaile, and Teec Nos Pos. The wind speed on the two remaining days was lighter and the primary direction was from 190 degrees. Consequently the dust plume traveled toward the north-northeast, with impacts likely limited to the communities of Second Mesa, Keams Canyon, Dilkon, and Pinon. Perhaps the most significant impact was to travel, because Interstate 40 was closed on all six of these days from approximately 17 miles west of Winslow (near the Meteor Crater exit) to Winslow.

Figure 5 also suggests that a relationship exists between wind speed and the distance that the plume travels from its point of origin. This relationship was calculated based distance measurements from the composite image in Figure 5 for each of the six dates shown. It should be no surprise that the stronger the wind was, the farther the dust traveled, as shown in Figure 6. Keep in mind we are limited to 6 cases due to cloud cover obscuring the dust plume during other events. As future events occur, more cases can be added to increase the accuracy of the regression analysis.

A positive correlation of wind speed to distance was determined to be 0.88. Given the relatively strong dependence of distance to wind speed, the authors feel confident that wind speed can be used as a good predictor of how far dust will travel during future wind events. Thus, forecasters can better predict which locations will be impacted by dust based on predicted wind speed and direction, assuming that the future dust point of origin is also known.

Forecast Wind Speed (MPH)	Distance Dust May Travel (Miles)
40	25
50	70
60	110
70	155
80	200

Table 2

To that end, a simple linear regression equation was developed based on the events highlighted in Figure 5 (distance being the dependent variable and wind speed the independent variable). The regression yielded the following equation:

$$\text{Distance in miles} = -146.742 + 4.3 (\text{wind speed in MPH})$$

(Figure 53, continued)

The values in Table 2 were calculated based on the preceding regression equation, and can be used as forecast guidance in advance of future high wind events.

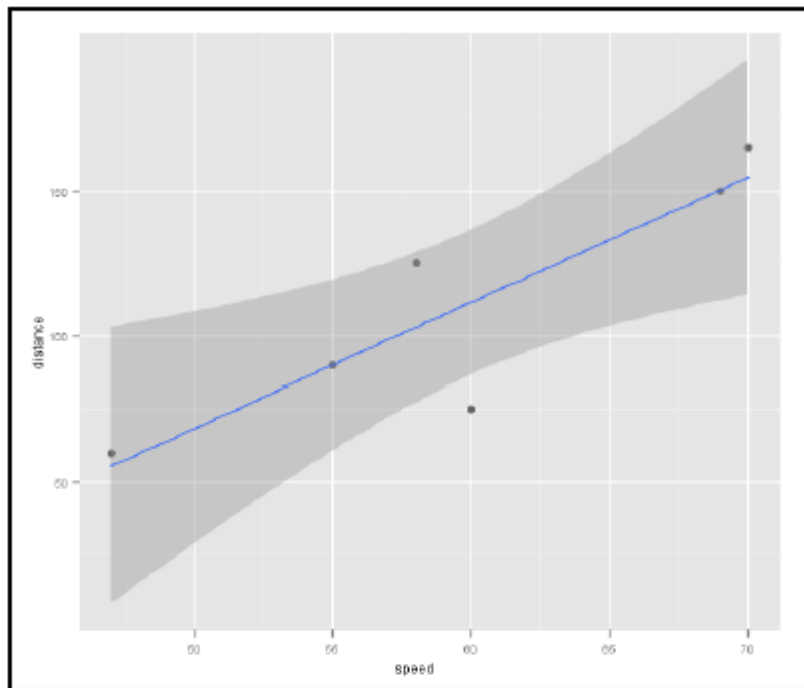


Figure 6 Wind speed (MPH) vs. distance (Miles) that the dust traveled based on the 6 events shown in Figure 5

Using these approximations, operational forecasters may be able to better determine which communities will be impacted by dust during an impending high wind event based on wind speed and direction.

Another interesting finding was that 27% of the cases involving severe blowing dust were followed by light precipitation. This makes meteorological sense given a stronger synoptic system will likely consist of stronger surface wind speeds, and often in advance of an eastward progressing cold front, high winds will be observed prior to precipitation onset with the frontal passage.

Additionally, a significant contributing factor to the frequency of the dust events, especially in 2010, may have been the ongoing drought conditions. This study revealed 55% of all severe blowing dust cases were preceded by moderate to severe drought conditions as reported by the U.S. drought monitor. Other research studies have shown a correlation with ongoing drought conditions with synoptically driven dust events (Rivera, 2006), and this may be a contributing reason as to why 2009 and 2010 featured such an increase in dust events as opposed to prior years.

(Figure 53, continued)

Forecast Tools

The Global Ensemble Forecast System (GEFS) can provide support in anticipating the magnitude of an incoming wind event and assessing the potential for dust. Figure 7 depicts the standardized anomalies forecast by the GEFS from its 00z Mar 21st, 2011 run; valid for 12z March 21st. This event produced 59 mph winds in Winslow, and 67 mph winds at Two Guns; however, no freeway closures occurred with this system. Anomalies across northern Arizona ran between three and four standard deviations above the normal, highlighting the strength of the incoming wind gradient.

The GEFS 700mb wind anomalies provide a great supplement to anticipate high wind potential, but further consideration of precipitation, cloud cover, and soil moisture may also influence the likelihood of blowing dust. On this day, despite high wind warning criteria being met across much of northern Arizona, blowing dust was very minimal due to the presence of light rain across the LCR and cloud cover limiting diurnal mixing. High wind events may occur under much less anomalous thresholds if mixing is more favorable and the strongest 700mb winds are juxtaposed with the midafternoon hours.

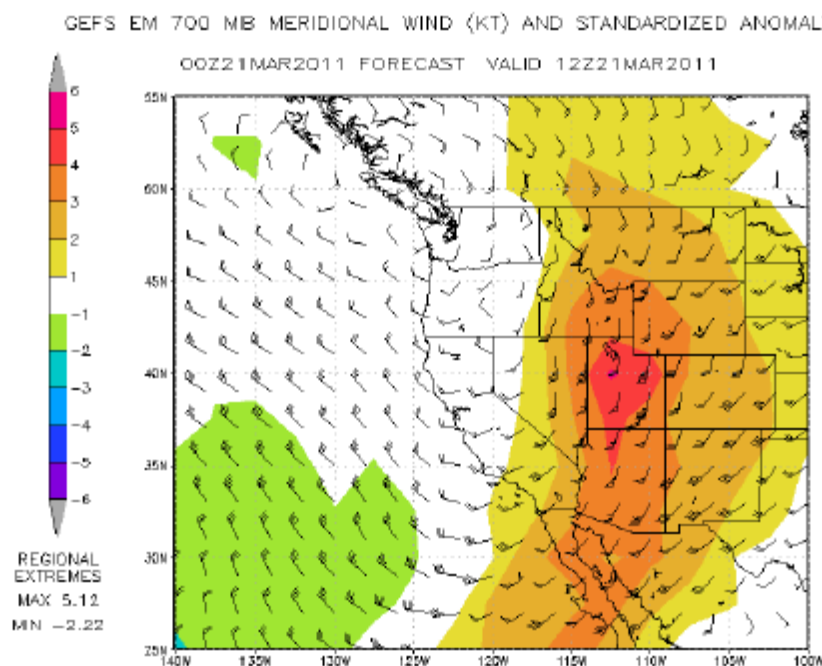


Figure 7 – GEFS 700mb standardized anomalies

(Figure 53, continued)

2011 Events

Despite having numerous high wind events, the spring of 2011 featured very little in the way of significant blowing dust and no interstate or highway closures. While this may seem counterintuitive to the research presented thus far, it actually supports the theory that high wind warning criteria winds are more conducive to severe blowing dust. While numerous wind events plagued the LCR over the course of the spring, the magnitude of the wind was much less than observed the previous two years. The table below shows the number of wind advisory and high wind warning days impacting the LCR for the spring months (Mar-Jun). Note that despite the high number of wind advisory days, the number of high wind warnings was less in 2011 than in 2010 and 2009, supporting the conclusion that a greater magnitude of wind is required for significant lofting of blowing dust.

<i>Year</i>	Wind Advisories	High Wind Warnings	I-40 Closures
<i>2011</i>	27	2	0
<i>2010</i>	15	6	7
<i>2009</i>	12	5	5

Furthermore, table A-2 (Appendix) shows a sampling of the wind storms between 2009 and 2011. Notice that despite the high number of wind events occurring in the spring of 2011, majority of them were wind advisory level wind, and none created blowing dust significant enough to cause interstate closures.

Conclusions

The 2009 and 2010 dust storms proved how vulnerable the LCR can be to synoptically forced dust events, but while they can develop suddenly and become high impact, they are highly predictable as well. Anytime a wind event is forecast across northeast Arizona, potential for blowing dust must be a consideration, and whenever a high-end wind event is anticipated, blowing dust becomes quite likely. One of the key findings indicated that most wind advisory days will not observe visibility reductions due to dust that will close the interstate. However, high wind warning days are much more likely to produce widespread blowing dust, which may result in interstate closures.

The lack of observation points was most definitely a limitation to this study, as Winslow and Two Guns represent a rather small sample size for winds across the LCR, but prove sufficient to gain insight into the wind magnitudes required for blowing dust. Further research into changes in land use across northeast Arizona and the associated role it may be playing in these dust storms would be beneficial, but it appears the Little Colorado riverbed is the primary source for much of the blowing dust across the LCR. Other tributaries and watersheds across the LCR may

(Figure 53, continued)

be secondary source regions influencing blowing dust across the Winslow and Two Guns regions. Ongoing drought conditions may have aided the severity of blowing dust, but wind speed is the primary determining factor when anticipating severe dust storm events.

(Figure 53, continued)

Appendix 1

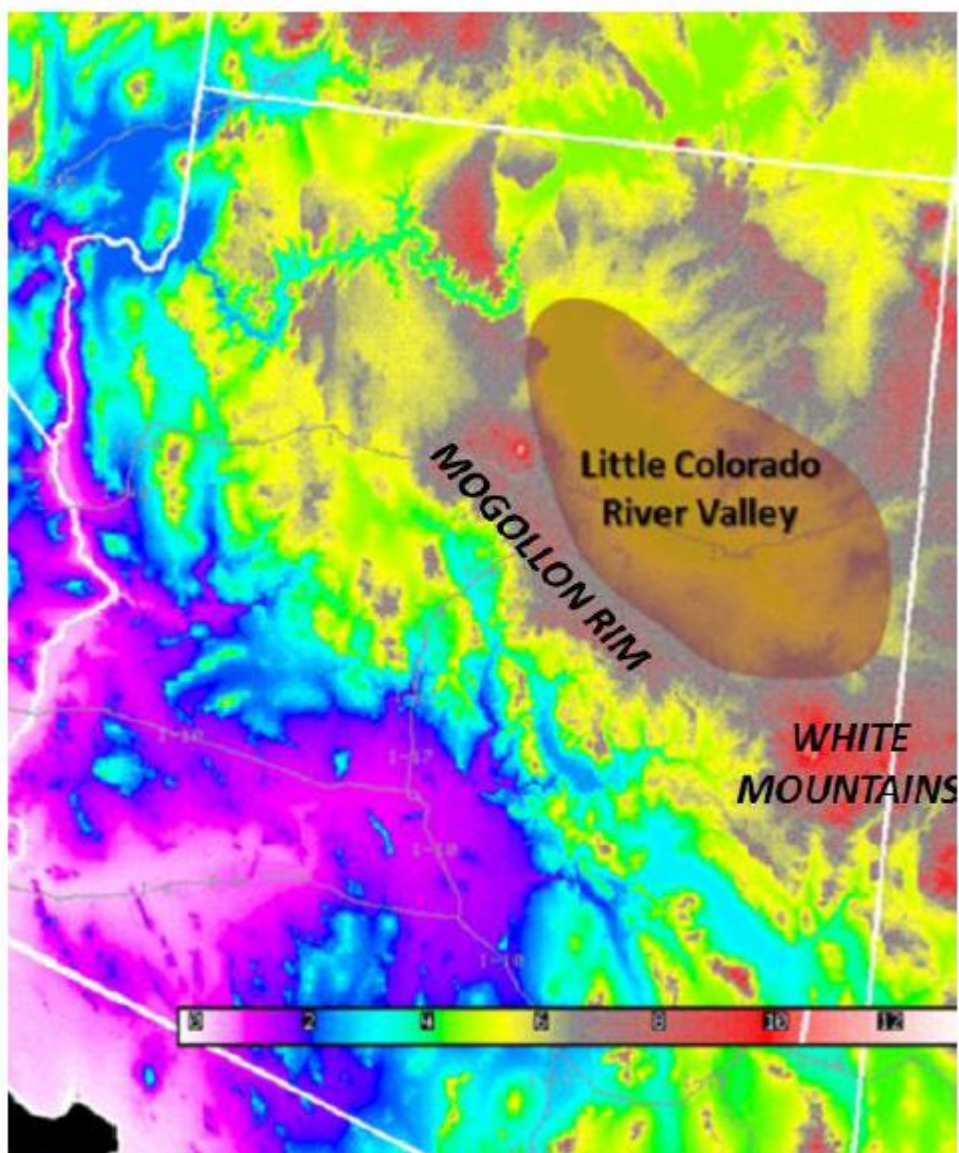


Figure A-1. Northern Arizona topography and location of Little Colorado River Valley

(Figure 53, continued)

Interstate 40 closures Due to Dust

Date	Highway Segment Affected (Mile Markers and Length)	Other Roads Closed
March 26, 2009	235-252 / 17 miles	SR 77 North of Holbrook
April 3, 2009	235-252 / 17 miles	
April 8, 2009	235-252 / 17 miles	
April 14-15, 2009	235-252 / 17 miles	
April 25, 2009	235-252 / 17 miles	
April 5, 2010	235-252 / 17 miles	Coconino Co Rd 505 to Luepp
April 12, 2010	235-252 / 17 miles	Coconino Co Rd 505 to Luepp
April 21, 2010	235-252 / 17 miles	Coconino Co Rd 505 to Luepp
April 28-29, 2010	230-252 / 22 miles	Coconino Co Rd 505 to Luepp
May 9, 2010	230-252 / 22 miles	
May 11, 2010	219-252 / 33 miles	Coconino Co Rd 505 to Luepp
May 22-23, 2010	219-252 / 33 miles	Coconino Co Rd 505 to Luepp

Table A-1

(Figure 53, continued)

Dust Event Wind Statistics

Date	I-40 Closure	Primary Wind Direction at KINW	Peak Wind Speed at KINW / Two Guns (MPH)
March 4, 2009	No	220	48/53
March 9, 2009	No	210	43/58
March 22, 2009	No	200	62/65
March 26, 2009	Yes	300	61/48
March 29, 2009	No	230	56/63
April 3, 2009	Yes	240	69/65
April 8, 2009	Yes	210	58/58
April 14, 2009	Yes	210	39/M
April 15, 2009	Yes	190	59/M
April 25, 2009	Yes	210	58/60
April 28, 2009	No	210	39/35
May 2, 2009	No	250	40/47
March 4, 2010	No	200	38/45
March 25, 2010	No	220	35/37
March 26, 2010	No	250	49/55
March 30, 2010	No	220	41/45
March 31, 2010	No	210	55/62
April 5, 2010	Yes	210	63/71
April 12, 2010	Yes	190	55/51
April 21, 2010	Yes	190	53/60
April 28-29, 2010	Yes	220	70/73
May 5, 2010	No	230	40/45
May 6, 2010	No	230	40/45
May 9, 2010	Yes	210	47/48
May 11, 2010	Yes	230	58/77
May 18, 2010	No	230	29/45
May 22, 2010	Yes	210	47/56
May 23, 2010	Yes	190	60/60
May 27, 2010	No	200	40/39
Mar 7 th , 2011	No	210	58/54
Mar 17 th , 2011	No	210	37/42
Mar 21 st , 2011	No	190	59/67
Apr 3, 2011	No	220	56/57
Apr 8, 2011	No	190	58/65
Apr 13, 2011	No	220	35/42
Apr 18, 2011	No	220	50/47
Apr 23, 2011	No	220	39/41
Apr 24, 2011	No	230	47/49
Apr 29, 2011	No	230	48/45
May 8, 2011	No	200	41/47
May 9, 2011	No	210	44/42
May 15, 2011	No	200	40/45

(Figure 53, continued)

May 18, 2011	No	210	54/49
May 26, 2011	No	220	40/44
May 28, 2011	No	210	52/49
May 29, 2011	No	210	56/68
June 6, 2011	No	200	45/50
June 16, 2011	No	220	40/42

Table A-2

(Figure 53, continued)

References:

Arizona Department of Transportation (ADOT). Biotic Communities [Image]. 2010.

Arizona Department of Environmental Quality (ADEQ) (2009). The Impact of Exceptional Wind Events 'Unusual Winds' on PM₁₀ Concentrations in Arizona. Air Quality Division.

Novlan, D., Hardiman, M., Gill, T. 2006. A Synoptic Climatology of Blowing Dust Events in El Paso, TX from 1932-2005.

Rivera, Nancy I. 2006, Detection and Characterization of Dust Source Areas in the Chihuahuan Desert, Southwest North America.

Figure 53. Little Colorado River climatology paper.

5.0 Local Dust Control

The following control measures resulted in the area's attainment of the PM₁₀ NAAQS, and these measures should ensure continued maintenance of the PM₁₀ NAAQS through the year 2021, which is the duration of the maintenance period.

1. Control of Emissions through Road Paving

The Town of Pagosa Springs paved 6.5 miles of unpaved roads during 1992, 1993, and 1994 in order to reduce PM₁₀ emissions. This strategy was adopted locally in 1991 and included in State regulation in 1992 (Section I.B. of the "State Implementation Plan-Specific Regulations for Nonattainment - Attainment/Maintenance Areas (Local Elements)"). The rule was approved by EPA in 1994 and was removed from the Colorado regulation in 2000 as the paving requirements had been completed.

2. Street Sanding Controls

There is a requirement that any user that applies street sanding material on Highway 160 and Highway 84 in the Pagosa Springs attainment/maintenance area must use materials containing less than one percent fines. Users of street sand on these highways must also use 15 percent less sand than an established base sanding amount. These strategies were adopted in 1992 and approved by EPA in 1994, and they are defined in detail in Sections I.B. and C., respectively, of the "State Implementation Plan-Specific Regulations for Nonattainment - Attainment/Maintenance Areas (Local Elements) Regulations (5 CCR 1001-20).

3. Control of Emissions from Stationary Sources

Although there are no major stationary sources located in the Pagosa Springs attainment/maintenance area, the State's comprehensive permit rules will limit emissions from any new source that may, in the future, locate in the area. These rules include: 1) Regulation No. 3, "Air Pollution Emission Notices, Construction Permits and Fees, Operating Permits, and Including the Prevention of Significant Deterioration," 2) the "Common Provisions" regulation, and 3) Regulation No. 6, "Standards of Performance for New Stationary Sources."

The Common Provisions, and Parts A and B of Regulation No. 3, are already included in the approved SIP. Regulation No. 6 implements the federal standards of performance for new stationary sources. The maintenance plan makes no changes to these regulations. This reference to Regulation No. 6 shall not be construed to mean that this regulation is included in the SIP.

As indicated above, emissions from new or modified major stationary sources emissions of PM₁₀ are controlled under Regulation No. 3's nonattainment-area (NAA) new source review (NSR) permitting requirements. The NSR provisions require all new and modified major stationary sources to apply emission control equipment that achieves the "lowest achievable emission rate" (LAER) and to obtain emission offsets from other stationary sources of PM₁₀.

The EPA approval of the original PM₁₀ Maintenance Plan, effective on 08/14/2001, reinstates the prevention of significant deterioration (PSD) permitting requirements in the Pagosa Springs Attainment/Maintenance area. The federal PSD requirements are considered a relaxation from the NAA NSR requirements, as LAER is no longer required and is replaced by the less stringent "best available control technology" (BACT), along with the removal of the requirement to offset PM₁₀ emissions. The future reapplication of NAA NSR provisions appears unlikely in the Pagosa Springs Attainment/Maintenance area based on current PM₁₀ monitoring trends.

4. Federal Motor Vehicle Emission Control Program

The federal motor vehicle emission control program has reduced PM₁₀ emissions through a continuing process of requiring diesel engine manufacturers to produce new vehicles that meet tighter and tighter emission standards. As older, higher emitting diesel vehicles are replaced with newer vehicles, the PM₁₀ emissions in the Pagosa Springs area will be reduced.

5. Voluntary and State-Only Measures

In addition to the mandatory control measures discussed above, there are other activities that result in the reduction of PM₁₀ emissions that are not classified as “federally enforceable control measures.” Some notable examples include:

- The Town of Pagosa Springs has historically cleaned Highway 160 in town throughout the winter and spring using regenerative air vacuum sweepers. The frequency of this voluntary sweeping/cleaning has been about once after each street sanding deployment. For the future, the Town of Pagosa Springs has committed to regularly vacuum sweep/clean Highway 160 within four days of the roadway becoming free and clear of snow and ice following each street sanding deployment, as weather, temperature, and street conditions permit, between the intersections of Highway 84 to the east and 14th Street to the west.
- The Town of Pagosa Springs requires that all new developments have paved streets.
- The Town of Pagosa Springs encourages private businesses to properly clean/sweep private parking lots on a regular basis.
- Archuleta County commits to pave the unpaved portion of Hot Springs Boulevard from the existing pavement to the boundary of the airshed.
- Any owner or operator responsible for the construction or maintenance of any existing or new unpaved roadway which has vehicle traffic exceeding 200 vehicles per day in the attainment/maintenance area and surrounding areas must stabilize the roadway in order to minimize fugitive dust emissions. These State-wide requirements are defined in detail in Section III.D.2.a.(I) of the AQCC’s Regulation No. 1.

These strategies are considered to be voluntary local initiatives and State-only requirements, and are intended to reduce PM₁₀ emissions. These strategies are not intended to be federally enforceable.

6.0 Laboratory and Field Data



IML Air Science
555 Absaraka
Sheridan WY 82801

0007 CDPHE
LabNet ID: 11-U746
87062705
Report #: 11-556

Particulate Sampler Field Envelope

Network PAGOSA 3

Sampler ID 17386

Filter Number 7062705

PSTG

Sample Date 3-22-09

ΔP on	ΔP off
3.05	3.0

Time Off 90146

Time On 88708

Run Time _____

Tech. _____

Comments:



IML Air Science

2009-10-15
Custer, NE - at Ranch
22-01-09
Ranch Top, 1000 ft

Particulate Sampler Field Envelope

LAMAR POWER PLANT
Network

Sampler ID ^{Pm10} (#4) 10452

Filter Number 7063063

PSTG

Sample Date March 22, 2009

ΔP on	ΔP off
2.60	2.60

Time Off 69904

Time On 68466

Run Time 1438

Tech Ronald C. Moring

Comments:

Very Windy



IML Air Science
555 Absaraka
Sheridan, WY 82801

2007 CDIME
Labnet ID# 11-1764
97042191
Report #1 11-1764

Particulate Sampler Field Envelope

Network INT. CRESTED B. H.

Sampler ID 11110-2-12141

Filter Number 7062491

PSTG

Sample Date 3-22-09

ΔP on	ΔP off
2.7	2.7

Time Off 91857

Time On 90404

Run Time 1453

Tech. M. H. H.

Comments:

High Winds All Day
Lots of dust in the AIR
supposably from UTAH

7.0 Summary and Conclusions

Elevated 24-hour PM₁₀ concentrations were recorded across much of Colorado. Except for the readings in the Denver metropolitan area, all of the March 22, 2009 twenty-four-hour PM₁₀ concentrations were above the 90th percentile concentrations for their locations. *The Pagosa Springs concentration exceeds the 99th percentile, and a conservative estimate of the dust storm contribution to the total concentration is 199-211 µg/m³. This is evidence that the event was associated with a measured concentration in excess of normal historical fluctuations including background. But for the dust storm described in detail in this report, there would have been no exceedance on this day in Pagosa Springs.*

This exceedance was the consequence of strong southwesterly winds in combination with dry conditions which caused significant blowing dust across much of northeast Arizona, northwest New Mexico, and southwest Colorado. *Surface winds of 20 to 50 mph with gusts of 25 to 62 mph were recorded across the Four Corners region on March 22, 2009. These speeds are above the thresholds for blowing dust identified in EPA draft guidance and in detailed analyses completed by the State of Colorado.*

Climatological data for March shows that most of the Four Corners area had received less than 50 percent of the normal precipitation for the month and northeast Arizona was abnormally dry. Hopi in northeastern Arizona received only 0.17 inches of precipitation during the 30 days prior to March 22, 2009. This total is well below the approximate threshold for blowing dust conditions at Hopi identified in the analysis contained in Attachment A. Both wind speeds and soil moisture in the Four Corners area and northeastern Arizona were conducive to the generation of significant blowing dust.

Friction velocities calculated for the region also help to explain why blowing dust originated in the Four Corners region and northeastern Arizona in particular. Even undisturbed desert soils normally resistant to wind erosion will be susceptible to blowing dust when friction velocities are greater than about 1.0 to 2.0 meters per second. A wide area of Arizona and New Mexico had friction velocities well above 1.0 meters per second late in the day. Some of the highest values were within the Little Colorado River Valley and Painted Desert region of northeast Arizona. *The computed friction velocities, measured wind speeds, and data on soil moisture conditions prove that this dust storm was a natural event that was not reasonably controllable or preventable.*

Satellite imagery shows large plumes of southwest to northeast trending blowing dust in the Painted Desert and Little Colorado River Valley region of northeastern Arizona on March 22, 2009. Forward and backward trajectories, wind streamline analyses, and surface and upper-level wind patterns show that this dust would have been transported into Colorado on March 22, 2009. An analysis run of a high-resolution meteorological model also shows winds flowing across northeast Arizona and Northwest New Mexico into Colorado. This analysis indicates that the zone of highest speeds targeted the Painted Desert and Little Colorado River Valley areas of northeastern Arizona – areas shown in Attachment A to be a significant source region for blowing dust transported into Colorado. *Multiple sources of data and analyses of past dust storms in this area prove that this was a natural event and, more specifically, a significant natural dust storm originating in northeastern Arizona and northwestern New Mexico. But for the dust storm on March 22, 2009, this exceedance would not have occurred.*

The Center for Snow and Avalanche Studies (<http://www.snowstudies.org/index.html>) has been studying the effects of desert dust deposition on snowpack albedo and snowmelt in the San Juan Mountains of Colorado. The center's log of events lists March 22, 2009 as one of twelve Dust-on-Snow events for the 2008/2009 water year. Reports and photos from Pitkin County environmental health staff and other data

indicate that desert dust from the Four Corners region moved as far north as Aspen, Colorado, during the evening of March 22. NOAA's Satellite Service Division also describes blowing dust moving from Arizona into southwest Colorado on March 22, 2009. *Multiple reports from professional experts at other institutions substantiate the conclusion that this was a natural event. But for the dust storm on March 22, 2009, this exceedance would not have occurred.*

8.0 References

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Draxler, R.R. and Rolph, G.D., 2012. HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) Model access via NOAA ARL READY Website (<http://ready.arl.noaa.gov/HYSPLIT.php>). NOAA Air Resources Laboratory, Silver Spring, MD.

Marticorena, B., G. Bergametti, D. Gillette, and J. Belnap, 1997, Factors controlling threshold friction velocity in semiarid and arid areas of the United States, *Journal of Geophysical Research* 102 D19, 23,277-23,287.

Rolph, G.D., 2012. Real-time Environmental Applications and Display System (READY) Website (<http://ready.arl.noaa.gov>). NOAA Air Resources Laboratory, Silver Spring, MD.

Technical Services Program, Air Pollution Control Division, Colorado Department of Public Health and Environment, November 22, 2011, *Technical Support Document for the January 19, 2009 Lamar Exceptional Event*.

United States Environmental Protection Agency, May 2, 2011, draft Guidance on the Preparation of Demonstrations in Support of Requests to Exclude Ambient Air Quality Data Affected by High Winds under the Exceptional Events Rule..

Attachment A - Grand Junction, Colorado, Blowing Dust Climatology.

There can be significant transport of regional blowing dust into Grand Junction from source regions in Utah and Arizona. While there are sources for wind-blown dust within the Grand Valley and Grand Junction itself, there is evidence from the analysis of soil features, wind and precipitation climatology, and statistical analyses of Grand Junction exceedances of the PM₁₀ standard that regional sources often play a significant role during these blowing dust events. This document provides a weight of evidence analysis for dust transport into Colorado.

Grand Junction, Colorado, is located in a part of the country that is largely arid to semi-arid. Figure A-1 through A-3 show the annual average precipitation for Colorado, Arizona, and Utah, respectively. Grand Junction is in the Grand Valley of Western Colorado where the annual precipitation is typically less than 10 inches. Northeastern Arizona, which is frequently upwind of Grand Junction during blowing dust events, receives between 5 and 15 inches of precipitation each year. The Colorado River Basin in eastern and southeastern Utah, which is also frequently upwind of Grand Junction during blowing dust events, also receives 5 to 10 inches per year.

Figure A-4 shows the 1971-2000 monthly normal precipitation amounts for Grand Junction, Colorado. The annual average for this time period is 8.99 inches. The wettest months are March through May and August through October. The driest months are January, February, June, July, November, and December. These months receive an average of 0.57 inches per month. The annual monthly average precipitation is 0.75 inches.

Arid to semi-arid soils make much of the region susceptible to blowing dust. The map in Figure A-5 shows that portion of the Colorado Plateau (circled in red) where modern wind erosion features are common and clearly visible in Google Earth images. These features include longitudinal dunes and other sand or soil erosion structures with a predominant southwest to northeast orientation. This orientation is the result of the predominant southwesterly flow that occurs during high wind and blowing dust events in the region. Figures A-6 through A-12 present aerial views of ubiquitous erosion features in northeastern Arizona and southeastern Utah. The Painted Desert of northeastern Arizona is frequently the source for much of the blowing dust in the Four Corners region. Figure A-13 provides a particularly good satellite image of a blowing dust event originating in the Painted Desert and extending northeastward across the junction of the Four Corners (source: NASA Tera satellite, <http://earthobservatory.nasa.gov/IOTD/view.php?id=37791>). Strong southwesterly winds caused this blowing dust event.

The text that accompanies this image on NASA's Earth Observatory 10th Anniversary page follows below:

“A dust storm struck northeastern Arizona on April 3, 2009. With winds over 145 kilometers (90 miles) per hour reported near Meteor Crater, east of Flagstaff, the storm reduced visibility and forced the temporary closure of part of Interstate 40, according to *The Arizona Republic*.

The Moderate Resolution Imaging Spectroradiometer ([MODIS](#)) on NASA's [Terra](#) satellite captured this image on April 3, 2009. Clear skies allow a view of multiple source points of this dust storm. The source points occur along an arc that runs from northwest to southeast.

This dust storm occurred in the area known as Arizona's Painted Desert, and the dust plumes show why. Whereas many dust plumes are [uniform in color](#), these plumes resemble a band of multicolored ribbons, ranging from pale beige to red-brown, reflecting the varied soils from which the plumes arise. The landscapes of the Painted Desert are comprised mostly of Chinle Formation rocks—remains of sediments laid down during the time of the first dinosaurs, over 200 million years ago.”

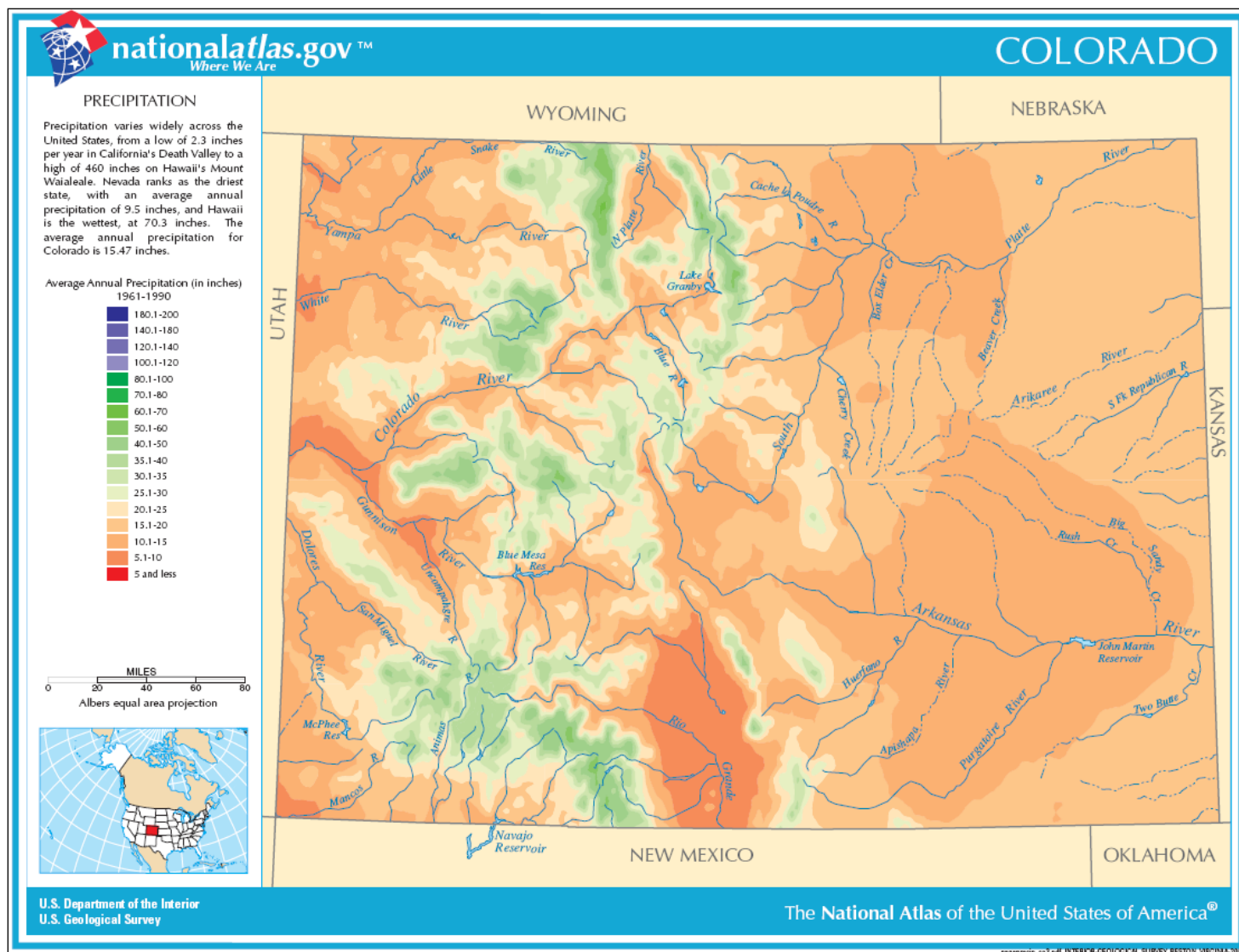


Figure A-1. Average annual precipitation in Colorado based on 1961-1990 normals.

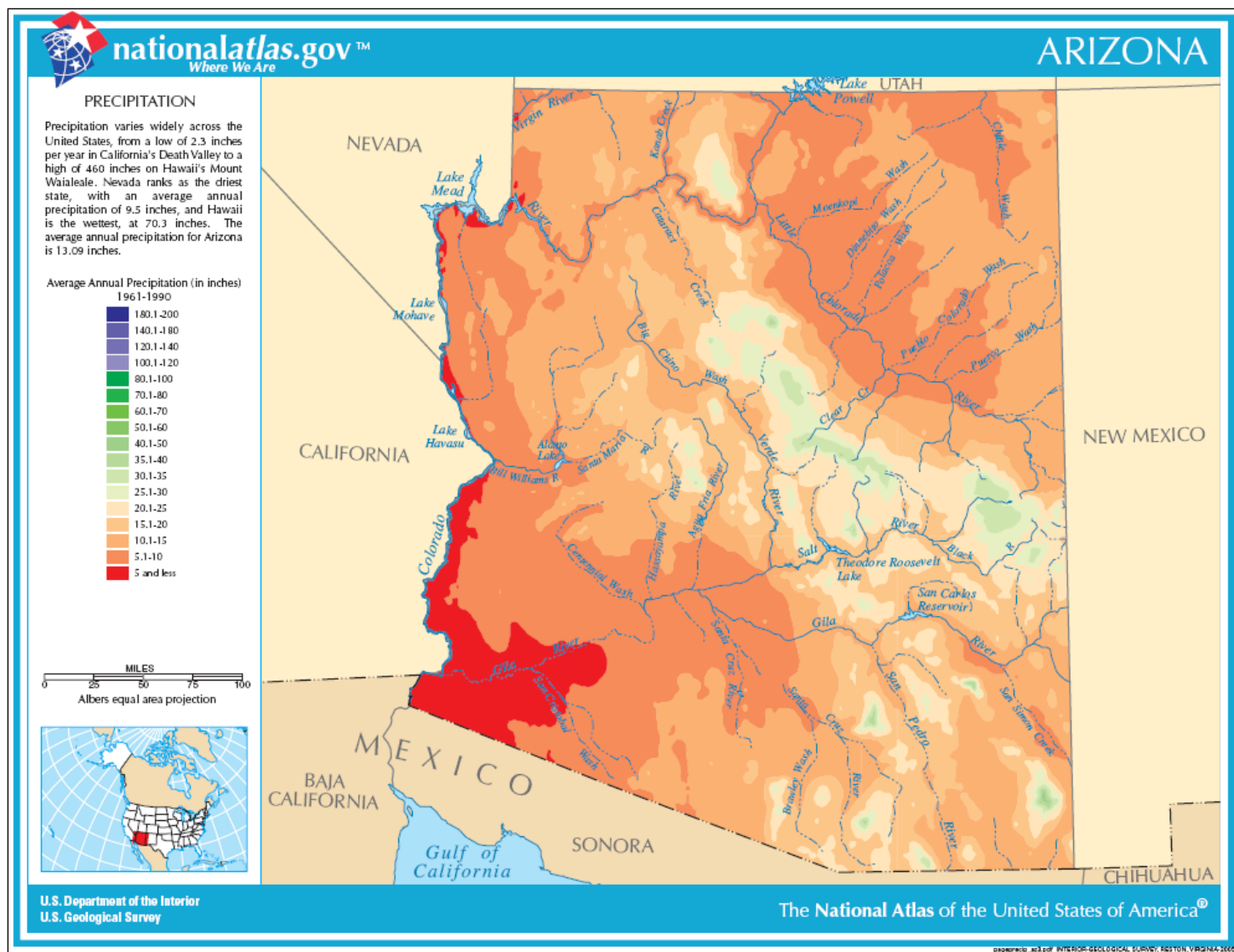


Figure A-2. Average annual precipitation in Arizona based on 1961-1990 normals.

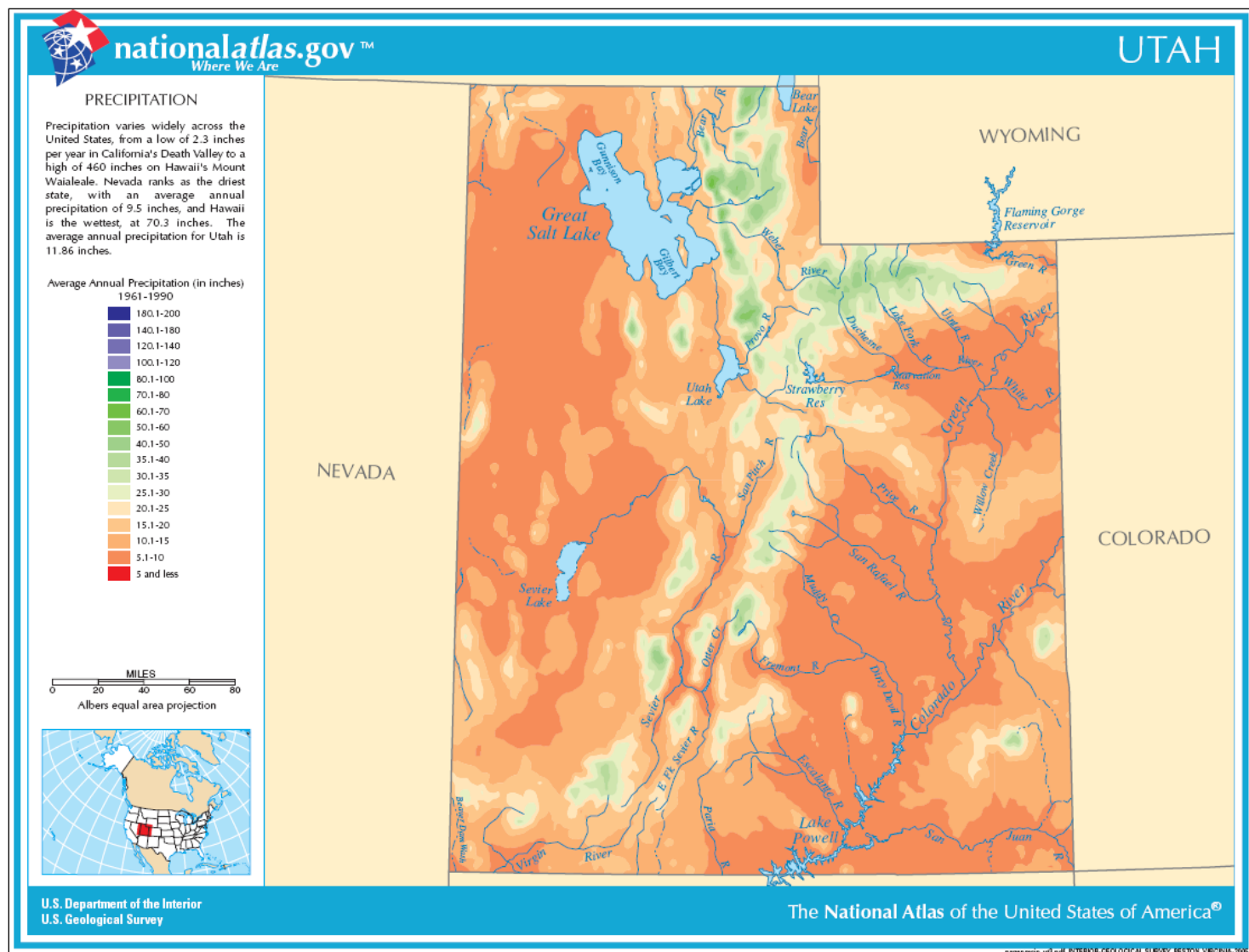


Figure A-3. Average annual precipitation in Utah based on 1961-1990 normals.

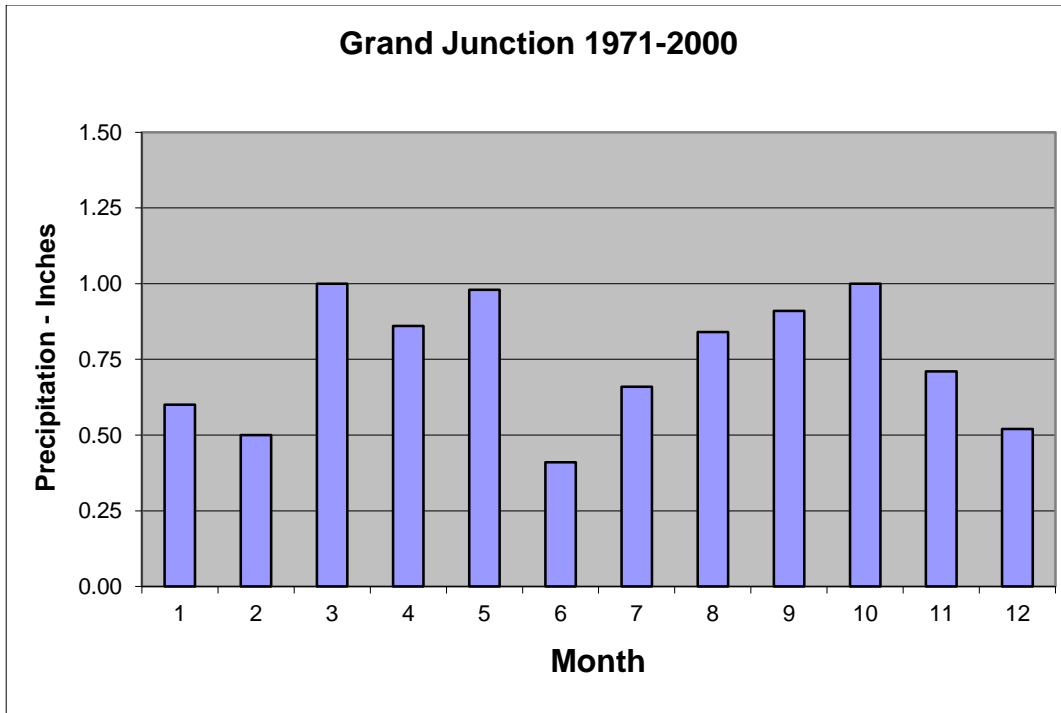


Figure A-4. 1971-2000 monthly normal precipitation in Grand Junction Colorado.



Figure A-5. The portion of the Colorado Plateau in Utah, Arizona, and New Mexico that exhibits widespread surface soil and sand erosion features in Google Earth imagery. Much of the highlighted area within Arizona is within the Painted Desert.

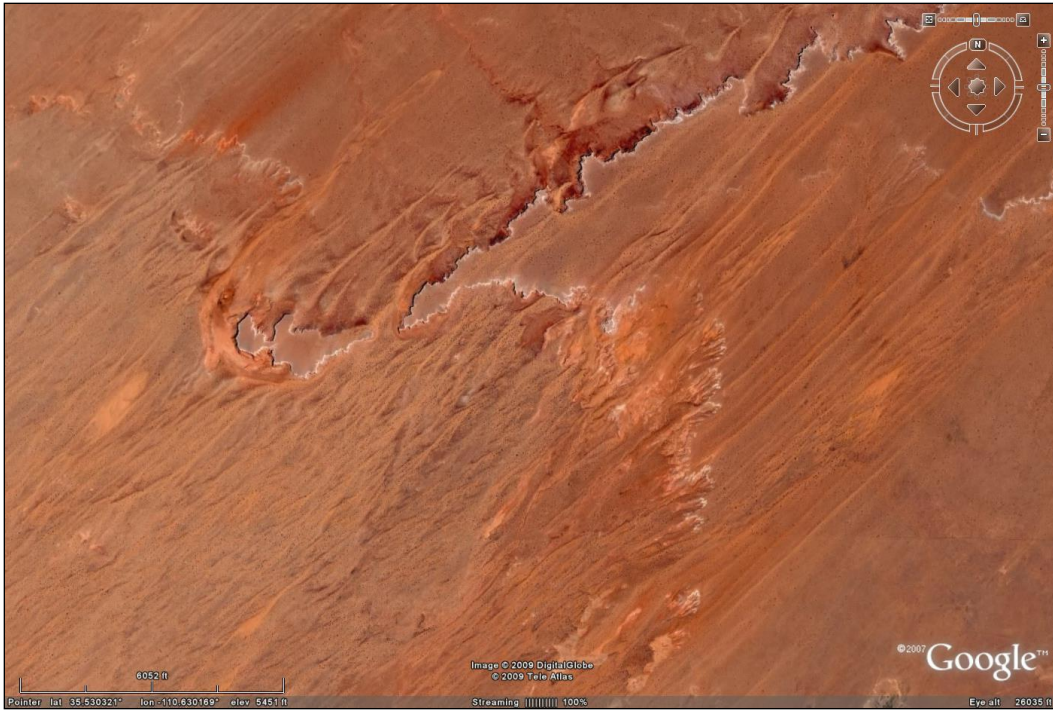


Figure A-6. Southwest to northeast soil and sand erosion structures in southeastern Utah.

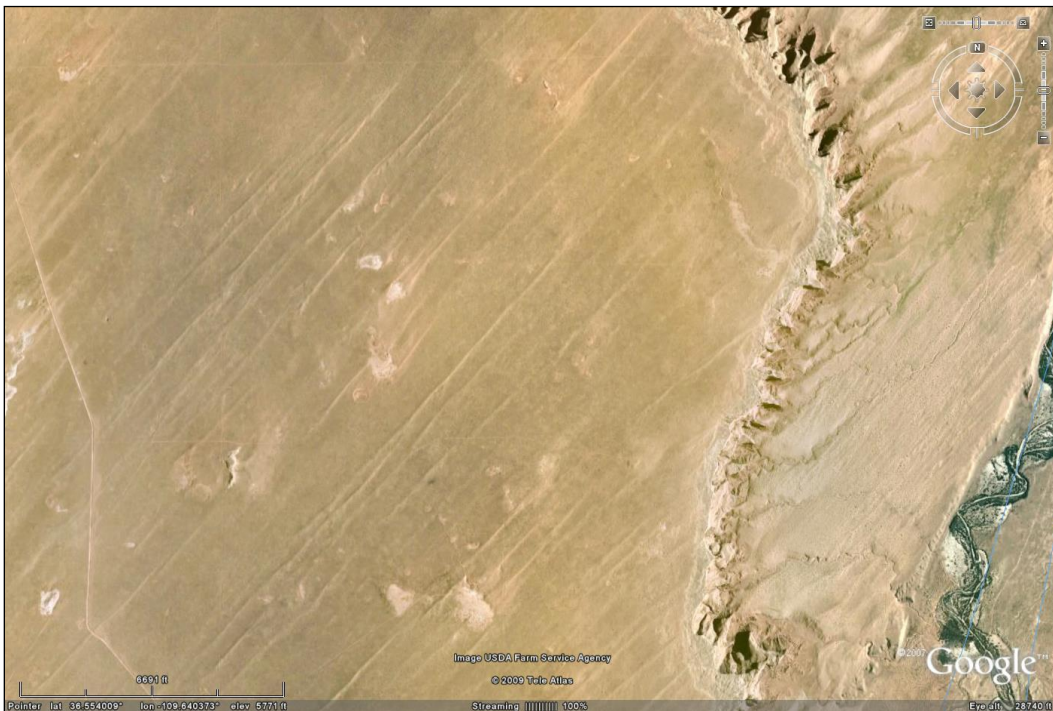


Figure A-7. Southwest to northeast soil and sand erosion structures in northeastern Arizona (Painted Desert).

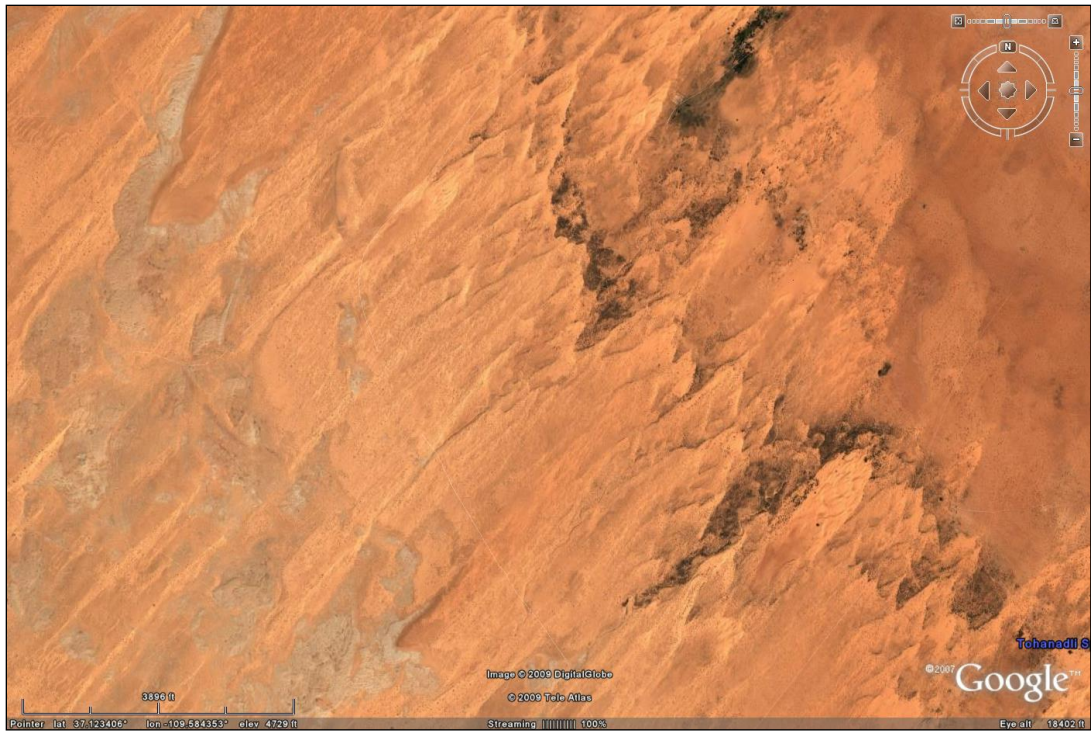


Figure A-8. Southwest to northeast soil and sand erosion structures in southeastern Utah.

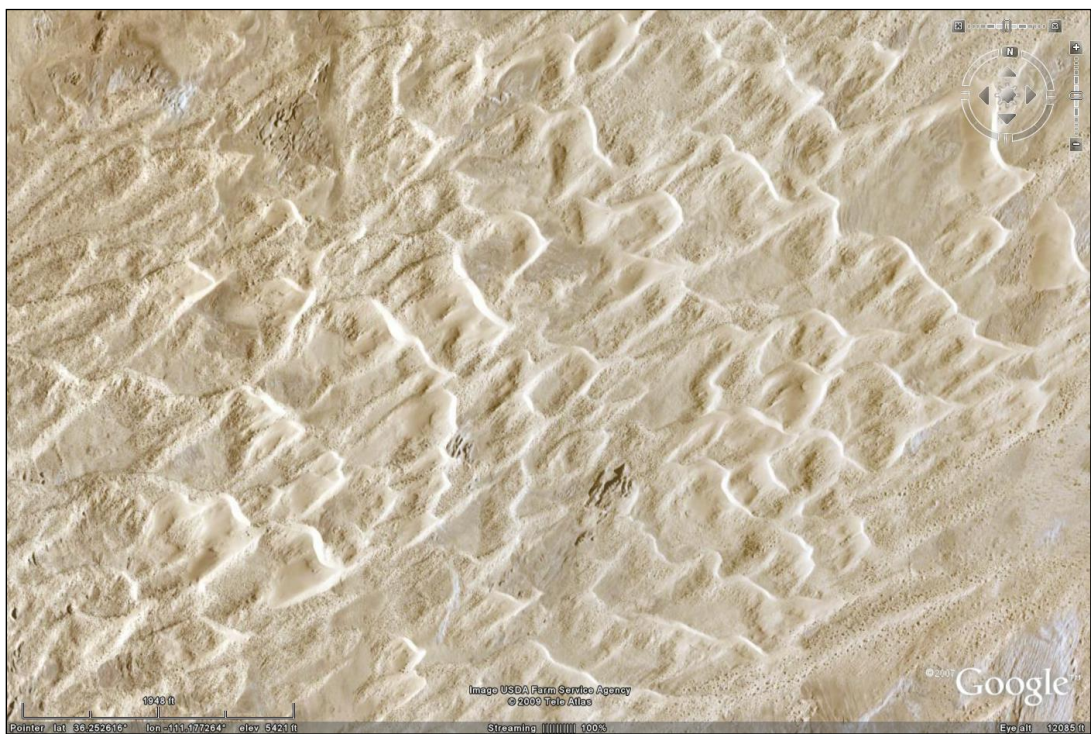


Figure A-9. Southwest to northeast soil and sand erosion structures in northeastern Arizona (Painted Desert). The slip faces of dunes (lighter bands) face in the direction of wind flow – toward the northeast.

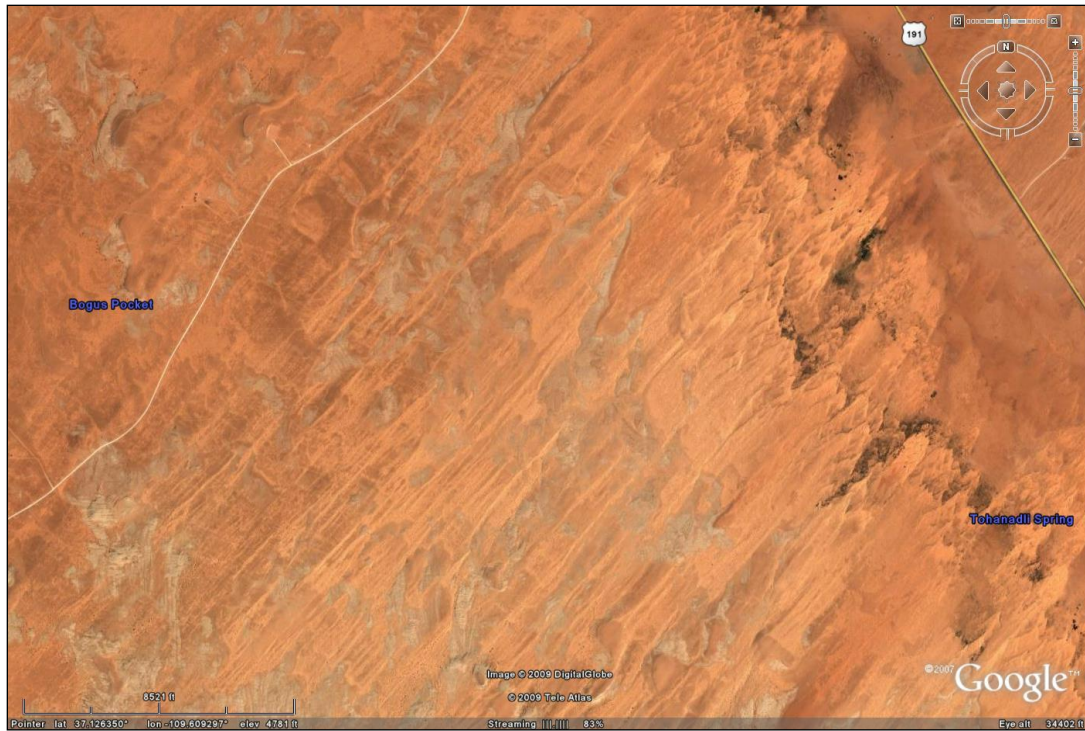


Figure A-10. Southwest to northeast soil and sand erosion structures in southeastern Utah.



Figure A-11. Southwest to northeast soil and sand erosion structures in northeastern Arizona (Painted Desert).



Figure A-12. Southwest to northeast soil and sand erosion structures in northeastern Arizona (Painted Desert).

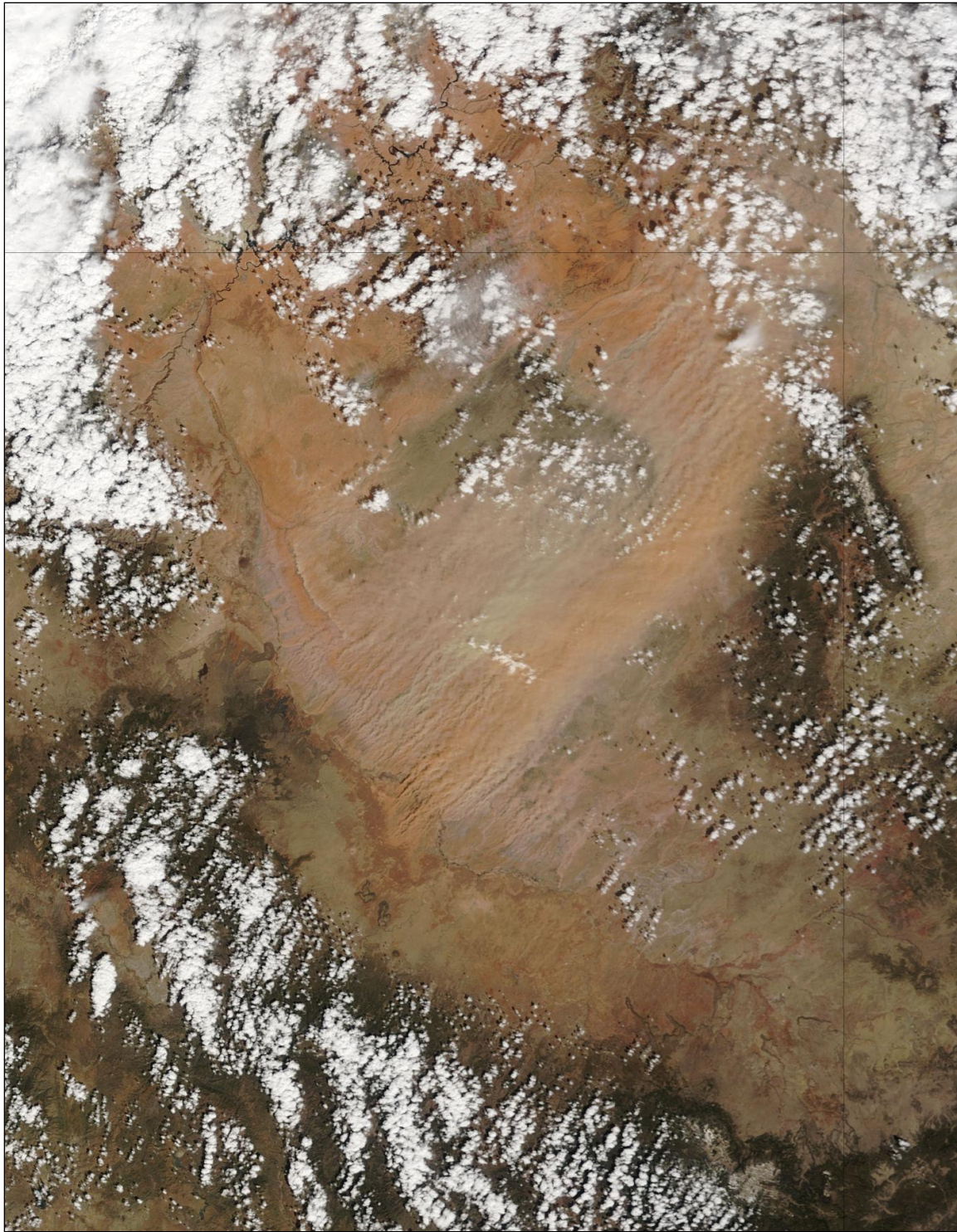


Figure A-13. NASA Tera satellite image of a dust storm on April 3, 2009, in southwesterly flow over the Painted Desert of northeastern Arizona (<http://earthobservatory.nasa.gov/IOTD/view.php?id=37791>).

Figure A-14 displays the surface weather map for this event (00Z April 4, 2009, or 5 PM MST April 3, 2009). A strong low pressure system in southern Colorado, strong southwesterly winds in the Four Corners area, and the blowing dust symbol (infinity sign) at Farmington (New Mexico) and Cortez (Colorado) are evident in this map. Blowing dust in this region is frequently associated with southwesterly flow.

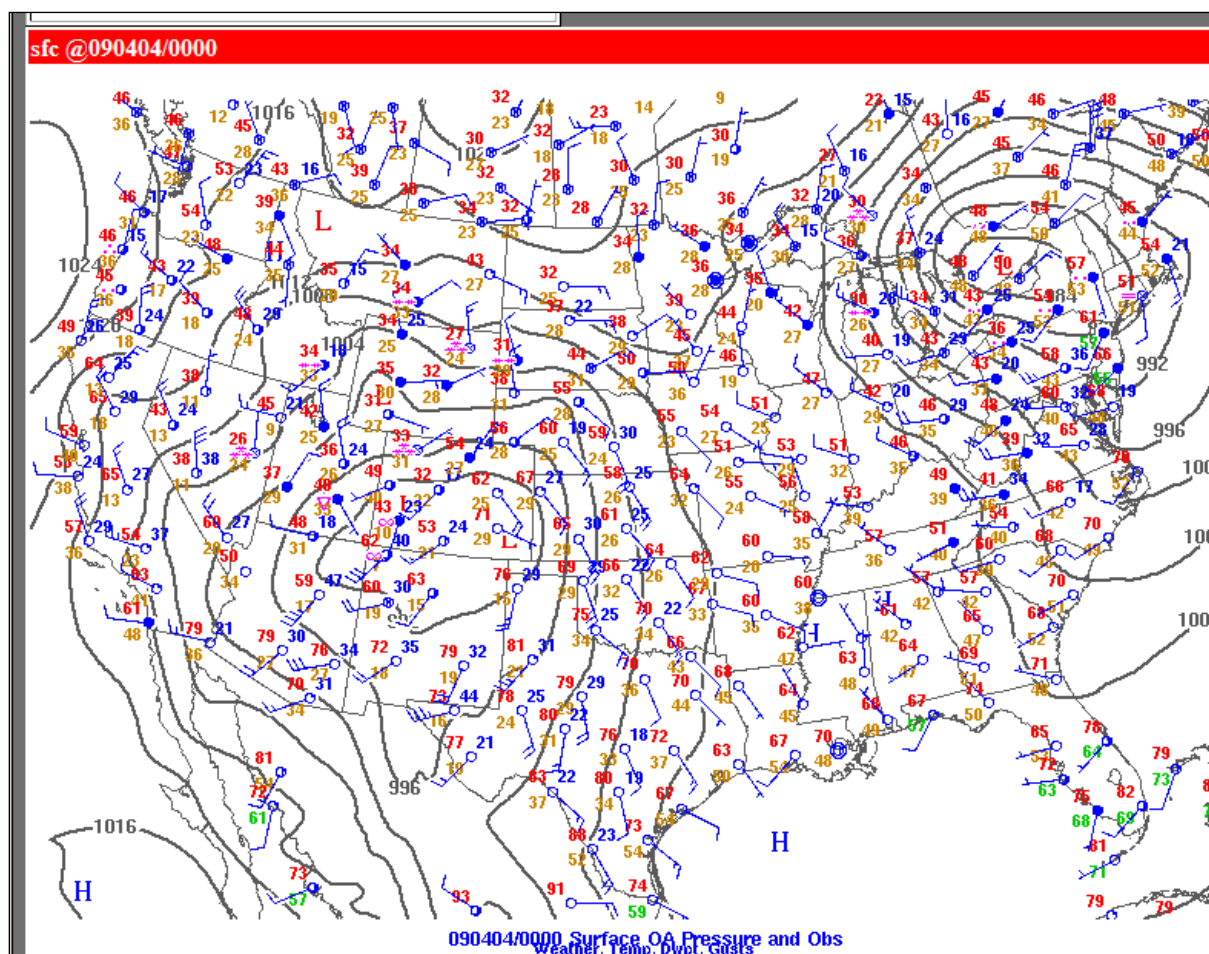


Figure A-14. Surface weather map for 00Z April 4, 2009, (5 PM MST April 3, 2009), showing a strong low pressure system in southern Colorado, strong southwesterly winds in the Four Corners area and the blowing dust symbol (infinity sign) at Farmington (New Mexico) and Cortez (Colorado).

A USGS map of the Colorado Plateau in Figure A-15 shows the prevalence of eolian or wind-blown sand deposits in southeastern Utah and northeastern Arizona. An analysis of the annual frequency of dust storms (Orgill and Sehmel, 1976) in the western half of the U.S. suggests that portions of eastern and western Utah and northeastern Arizona are source regions for blowing dust (see Figure A-16). Soil and sand structures point to the prevalence of southwesterly flow during blowing dust events, and precipitation climatology highlights the potential for blowing dust across much of the region. In addition, an analysis of back trajectories associated with high PM₁₀ concentration events in Grand Junction discussed in the next section of this document supports the conclusion that soils in Arizona and Utah are likely significant contributors to PM₁₀ measured during many dust storms affecting Grand Junction.

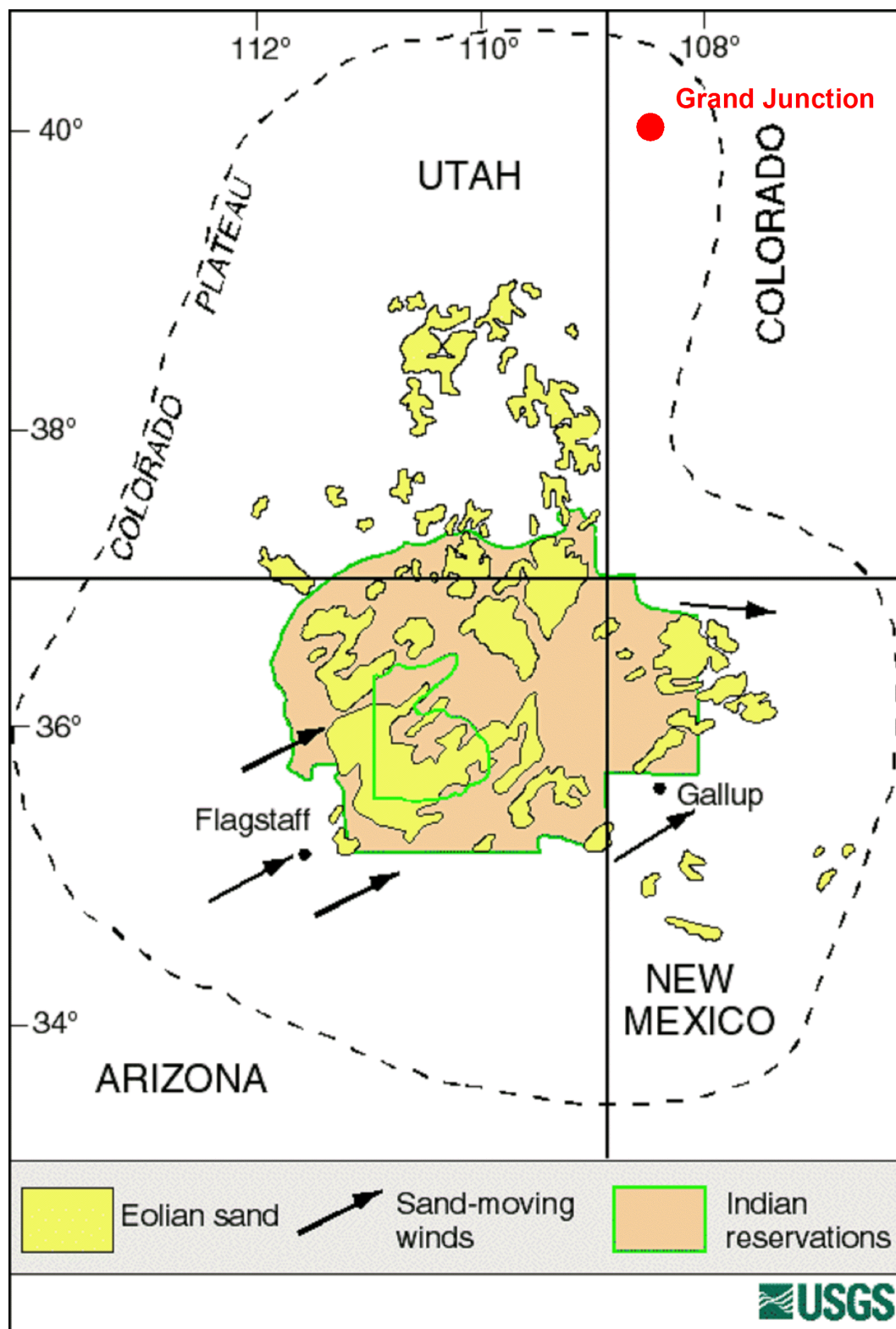


Figure A-15. USGS map of eolian sand features on the Colorado Plateau (<http://geochange.er.usgs.gov/sw/impacts/geology/sand/>).

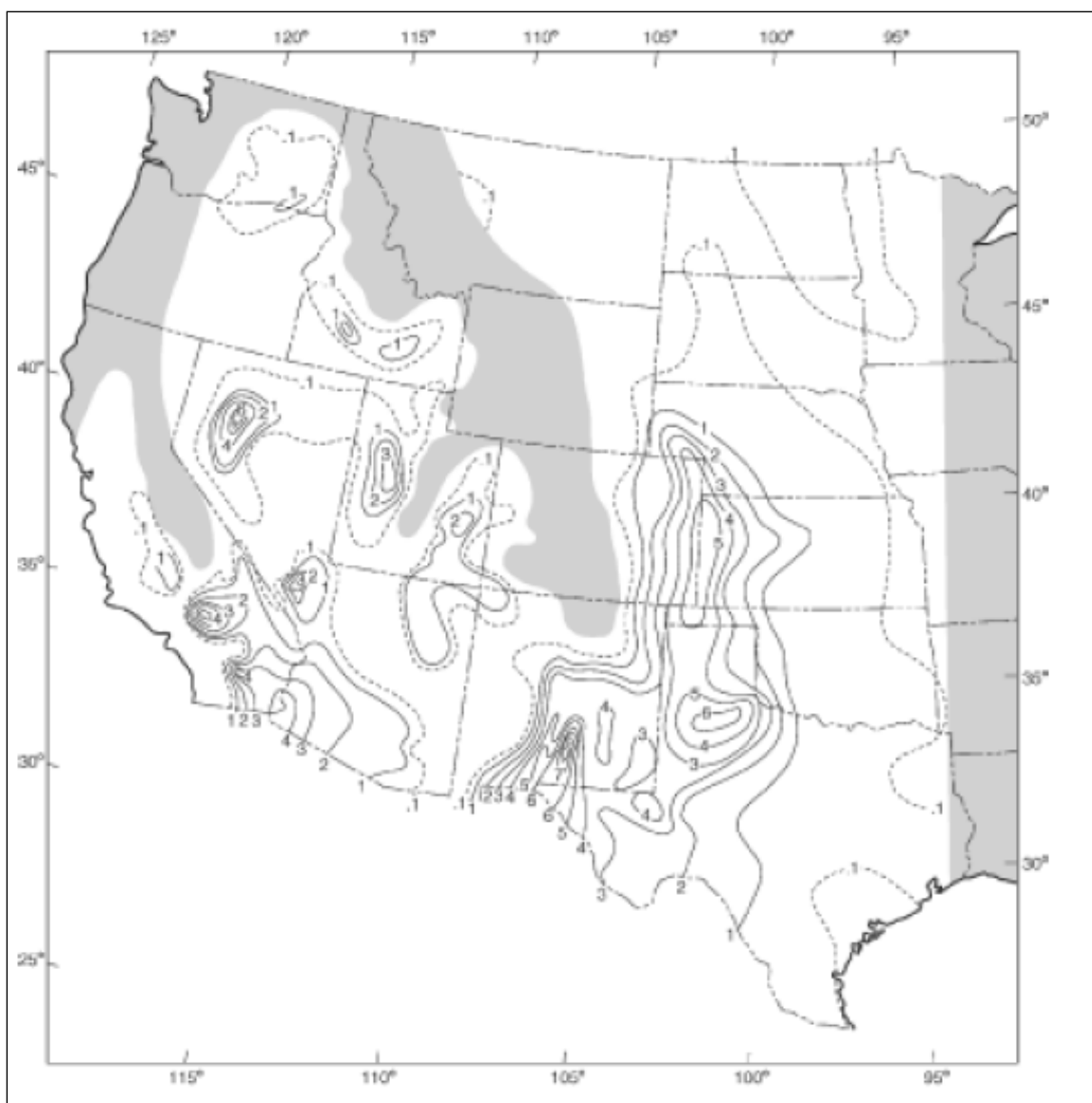


Figure A-16. Number of dust storms per year from: Orgill, M.M., Sehmel, G.A., 1976. Frequency and diurnal variation of dust storms in the contiguous USA. **Atmospheric Environment** 10, 813–825.

NOAA HYSPLIT 36-hour back trajectories were calculated for Grand Junction for the eight 24-hour periods from 2004 through early 2009 with the Powell monitor PM_{10} concentrations in excess of $75 \mu\text{g}/\text{m}^3$, strong regional winds, and dry soils. Trajectories were modeled every 4 hours for each day. Data presented later in this document provides evidence that the moderate to high PM_{10} levels on these days were from blowing dust. The 6 back trajectories for each day were calculated for an arrival height of 500 meters using EDAS40 data and model vertical velocities (see: <http://www.arl.noaa.gov/HYSPLIT.php>). The eight days used in the analysis and the Powell monitor concentrations measured on these days are presented in Table A-1.

The back trajectories for these high-concentration days are shown in Figure A-17. Transport was generally from the west through southwest. A high density of trajectory points is found in northeast Arizona and southeast Utah. Most of these trajectories in Figure A-17 are also consistent with transport

from or across suspected or known blowing dust source regions highlighted in Figures A-5, A-13, A-15, and A-16.

Table A-1. Grand Junction Powell monitor days with concentrations in excess of $75 \mu\text{g}/\text{m}^3$ and blowing dust conditions (from 2004 through early 2009).

Year	Month	Day	Powell 24-hour PM_{10} concentration in $\mu\text{g}/\text{m}^3$
2005	4	19	197.8
2008	4	15	116.1
2008	4	21	103.6
2004	9	3	102
2006	3	3	98.3
2008	5	21	86.7
2008	4	30	83.5
2006	6	7	77.9

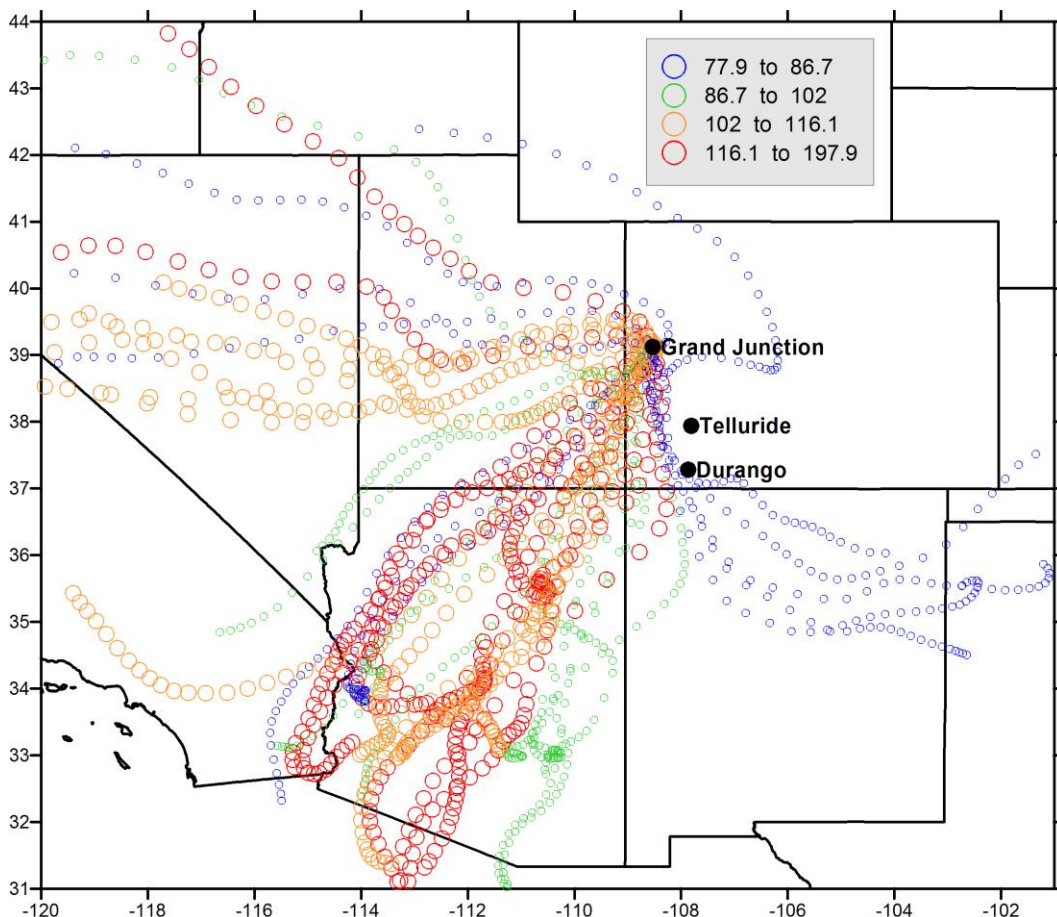


Figure A-17. NOAA HYSPLIT 36-hour back trajectories for Grand Junction for those eight 24-hour periods from 2004 through early 2009 with the Powell monitor PM_{10} concentrations in excess of $75 \mu\text{g}/\text{m}^3$, strong regional winds, and dry soils. Trajectory points are sized and color-coded to reflect 24-hour PM_{10} concentrations in $\mu\text{g}/\text{m}^3$. Trajectories were calculated every 4 hours for each day.

The trajectories in Figure A-17 point to the possibility that, at times, dust from Utah and Arizona can have a major impact on Grand Junction and less of an impact elsewhere in western Colorado. This non-homogeneity is possible given the fact that dust storms are frequently organized into discreet plumes from discreet areas that maintain their integrity for long distances. An example of this can be seen in Figure A-18 that shows plumes of dust in New Mexico during a windstorm on May 20, 2008.

Figure A-19 shows the NOAA HYSPLIT back trajectories for the highest concentration day during the 2004 through early 2009 period: April 19, 2005. Twenty-four hour back trajectories for each hour during the period with high winds (using EDAS40 data and 500-meter arrival heights) show that the back trajectories for Grand Junction were more likely to have crossed the Painted Desert and southeastern Utah than those for Telluride and Durango, which measured lower PM₁₀ concentrations on this day.

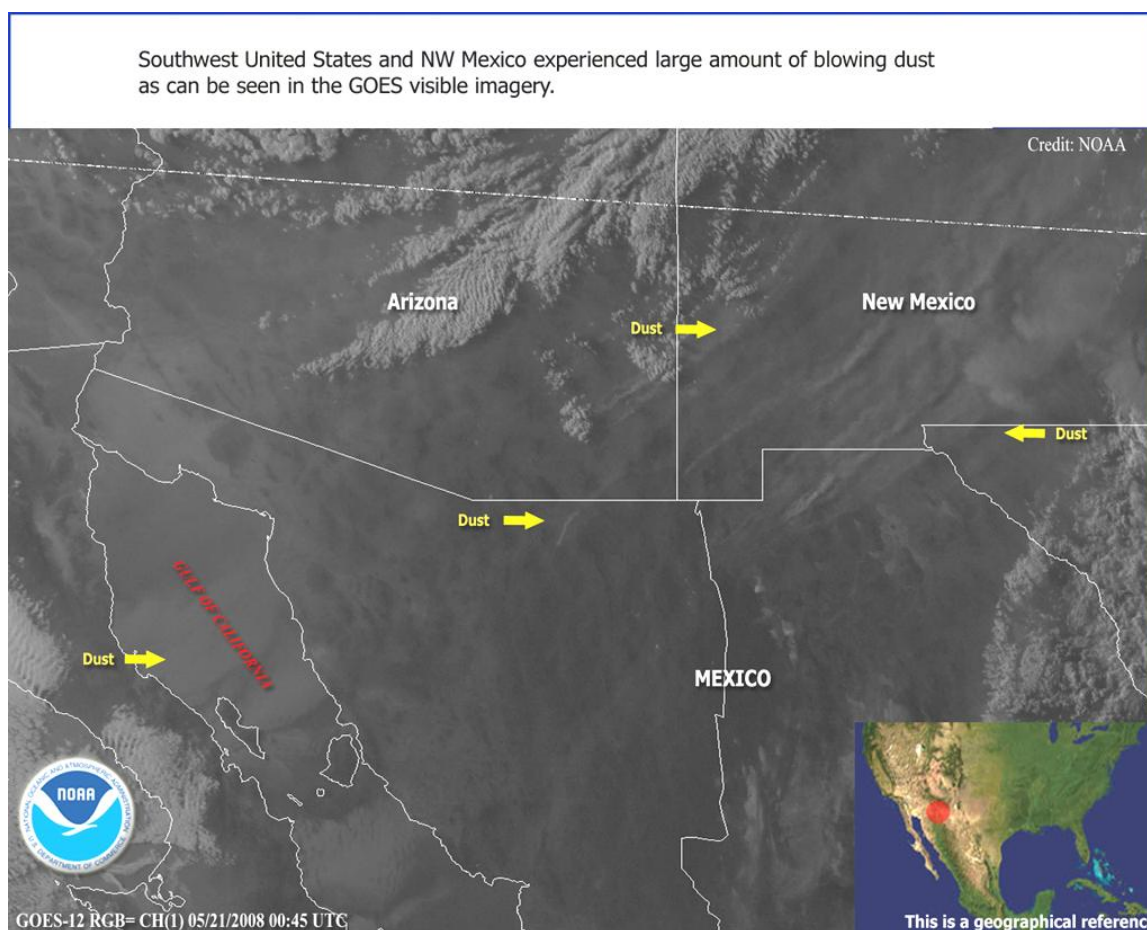


Figure A-18. Discreet plumes of blowing dust in New Mexico, Mexico, and Arizona visible in GOES satellite imagery for May 20, 2008 (http://www.osei.noaa.gov/Events/Dust/US_Southwest/2008/DSTusmx142_G12.jpg).

K-means cluster analysis has been applied to Grand Junction Powell PM₁₀ concentrations, Grand Junction and Painted Desert 30-day total precipitation for each PM₁₀ monitoring day, and Grand Junction and Painted Desert daily maximum wind gust speeds for each monitoring day. K-means cluster analysis is a statistical method for identifying clusters or groupings of values for many variables. For environmental variables, these clusters often represent distinct processes, conditions, or events. In this case, cluster analysis differentiates PM₁₀ concentrations associated with strong winds, low soil moistures, and blowing dust by providing mean values for these 5 variables for 5 distinct categories of PM₁₀ events. The period of record considered was from January 2004 through March

2009. The Hopi weather station located in the central portion of the Painted Desert was used to represent Painted Desert conditions in northeastern Arizona, and the Grand Junction National Weather Service station was used to represent Grand Junction conditions. The 30-day total precipitation values appear to be a better metric for blowing dust conditions than shorter-term totals.

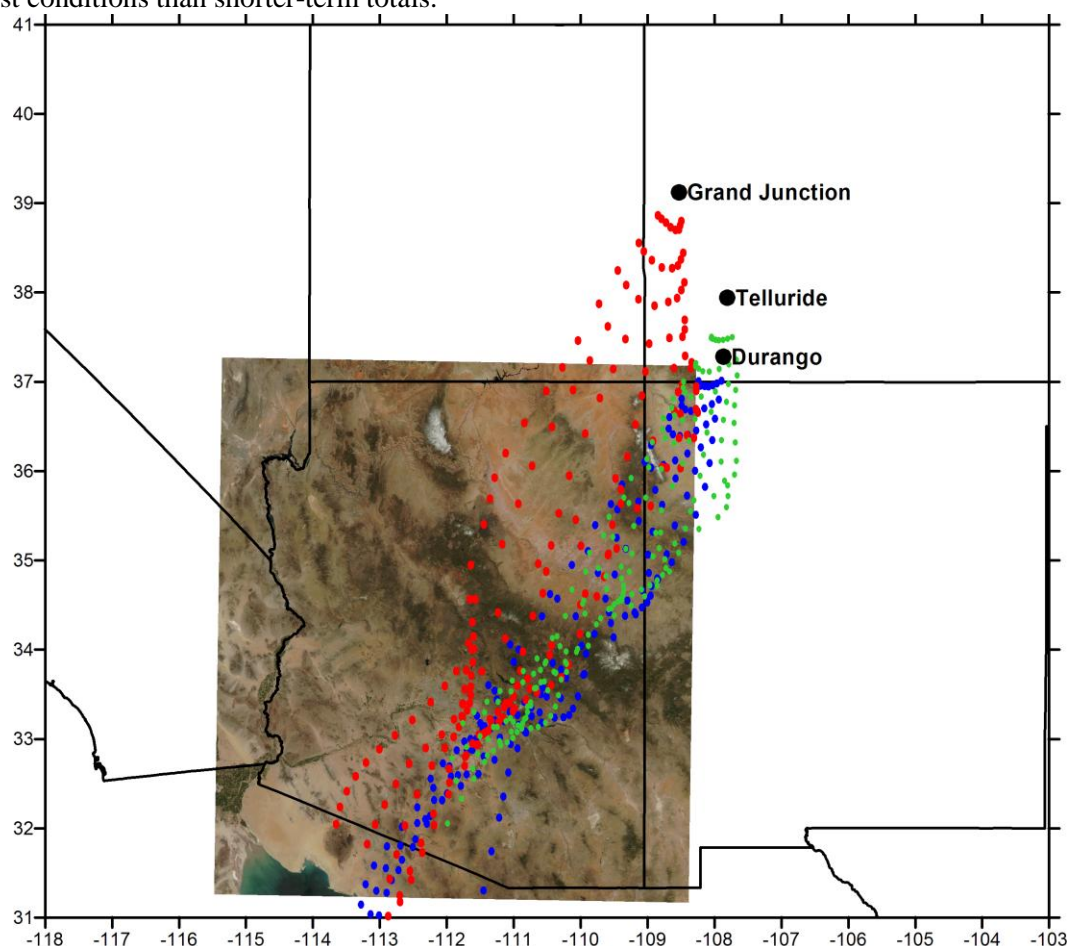


Figure A-19. 24-hour NOAA HYSPLIT back trajectories for every hour from 1500 MST to 2200 MST for Grand Junction (red), Telluride (green), and Durango (blue) for the dust storm of April 19, 2005.

The results of the cluster analysis are presented in Table A-2 below. Cluster 1 represents high soil moisture conditions, moderate gust speeds, and low PM_{10} concentrations. Cluster 2 represents very low soil moisture, moderate PM_{10} , and low gust speeds. Cluster 3 represents low soil moisture, moderate gusts, and low PM_{10} . Cluster 4 represents moderate soil moisture, low gusts, and low PM_{10} . Finally, Cluster 5 represents high PM_{10} , high gusts, and low soil moisture. Cluster numbers, Grand Junction Powell PM_{10} concentrations, and Grand Junction daily maximum gust speeds are plotted in Figure A-20.

The data in Figure A-20 clearly show that the highest PM_{10} concentrations tend to occur in Cluster 5 with gusts above 40 mph. The only exceedance in this period occurred on a day with a peak gust of 43 mph. Cluster 2 is likely to be indicative of wintertime inversion conditions with lighter winds and moderately elevated PM_{10} . Figure A-21 shows the concentrations and cluster values associated with Hopi station daily maximum gust speeds. The overall pattern is similar. The highest concentration day is associated with a peak gust of 47 mph at Hopi. All of the days/events presented in Figure A-17, A-19, and Table A-1 were classified as Cluster 5.

Table A-2. K-means cluster analysis means for Grand Junction PM₁₀ and meteorological variables.

Cluster Variables	Cluster 1 Means	Cluster 2 Means	Cluster 3 Means	Cluster 4 Means	Cluster 5 Means
Powell 24-hour PM ₁₀ in $\mu\text{g}/\text{m}^3$	24.5	37.3	24.3	21.8	74.9
Hopi Wind Gust in mph	20.8	18.0	32.5	20.7	40.5
Grand Junction Wind Gust in mph	20.4	16.5	31.8	19.6	43.1
Grand Junction 30-day Precipitation	1.7	0.4	0.5	0.8	0.6
Hopi 30-day Precipitation	1.8	0.2	0.5	0.7	0.3
Count	85	120	170	147	24

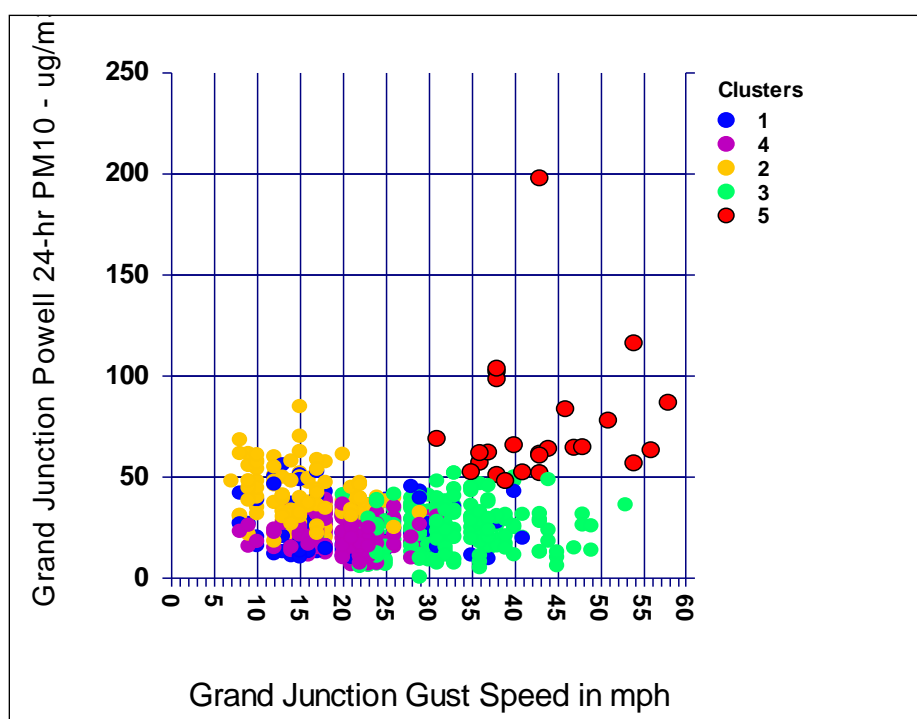


Figure A-20. Grand Junction Powell 24-hour PM₁₀ concentrations versus Grand Junction gust speed by cluster.

Figures A-22 and A-23 show Powell PM₁₀ concentrations versus Grand Junction and Hopi 30-day precipitation totals, respectively, by cluster. The blowing dust group, Cluster 5, is generally associated with 30-day precipitation totals of less than 1.00 inches at Grand Junction and less than 0.50 inches at Hopi. While this is not proof that the measured dust in Grand Junction is from Arizona, it adds to the weight of evidence that the Painted Desert makes a significant contribution to PM₁₀ concentrations in Grand Junction during many blowing dust events. Of interest in this regard are the two high concentrations (greater than 100 $\mu\text{g}/\text{m}^3$) that occurred when Grand Junction 30-day precipitation totals were greater than an inch (see Figure A-22). One of these occurred when transport was from the

southwest. On this day (April 21, 2008) the NOAA Satellite Smoke Text Archive reported the following (see <http://www.ssd.noaa.gov/PS/FIRE/smoke.html>):

“Blowing dust is seen over most of Utah (and part of western Nevada) and the dust is moving toward the northeast, reaching into northwestern Colorado and southern Wyoming.”

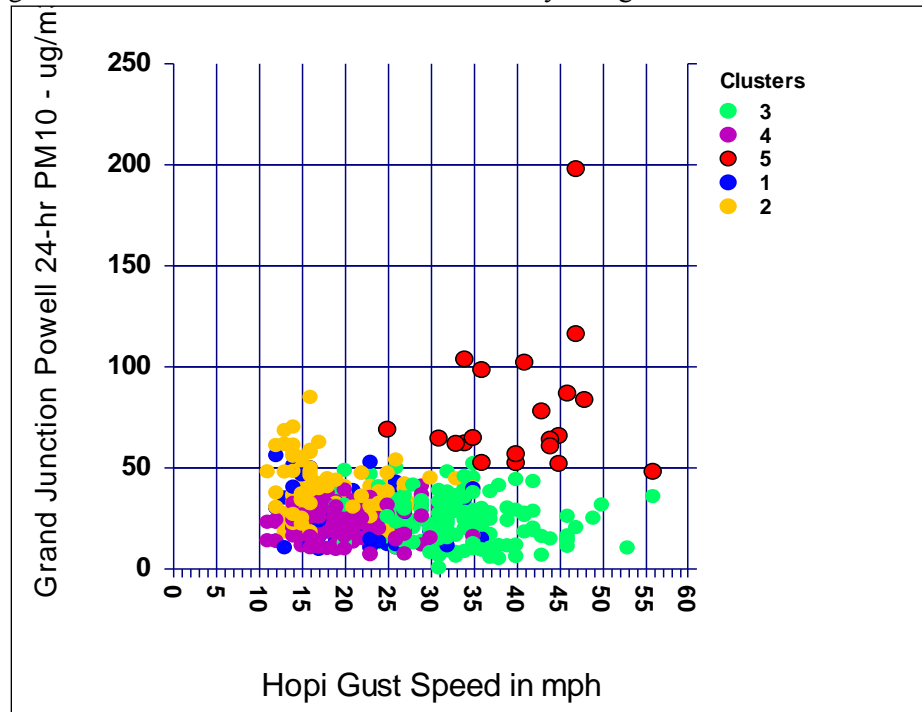


Figure A-21. Grand Junction Powell 24-hour PM₁₀ concentrations versus Hopi gust speed by cluster.

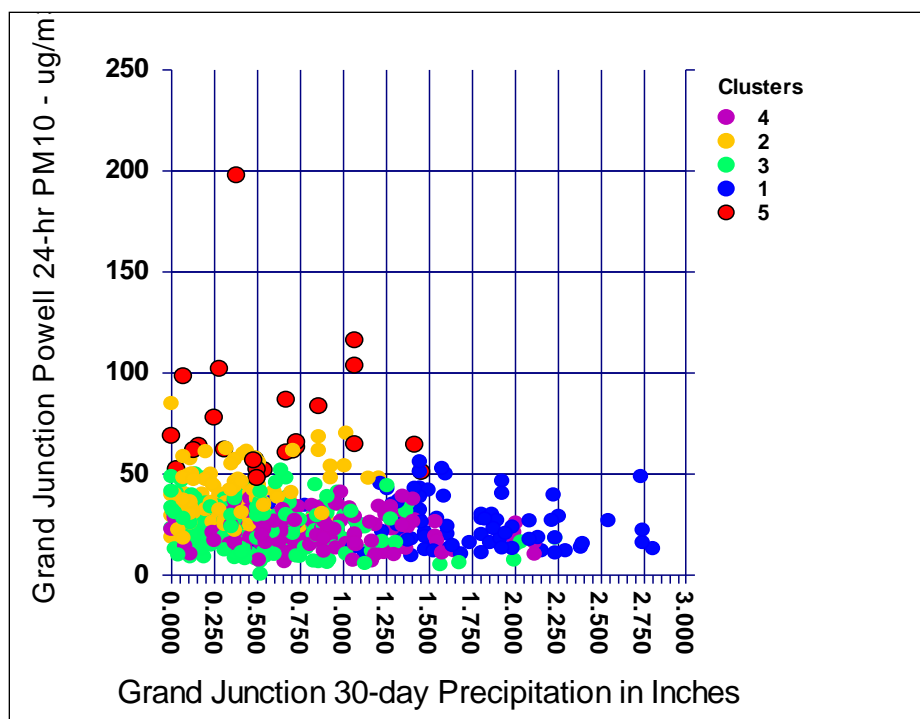


Figure A-22. Grand Junction Powell 24-hour PM₁₀ concentrations versus Grand Junction 30-day total precipitation by cluster.

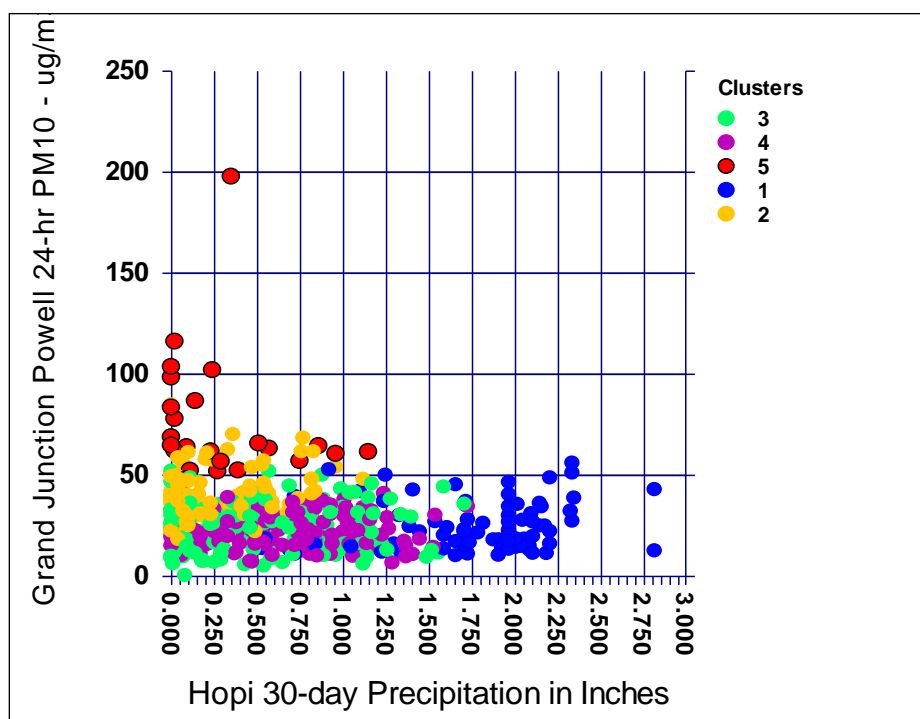


Figure A-23. Grand Junction Powell 24-hour PM₁₀ concentrations versus Hopi 30-day total precipitation by cluster.

The other occurred on April 15, 2008, when the flow was from Arizona and southeast Utah. The transport conditions, the discrepancy between high recent precipitation in Grand Junction and low recent precipitation at Hopi for these two days, and, in one case, analyst discussion of what was visible in satellite images suggest that much of the dust might have originated from outside of the Grand Junction environment.

Figure A-24 shows Grand Junction Powell 24-hour PM_{10} concentrations versus peak gust wind directions at the Little Delores RAWs weather station about 25 miles west-southwest of Grand Junction. Grand Junction is situated on the floor of the Grand Valley, a major northwest to southeast trending basin that can force or channel synoptic scale flows. As a result, surface wind directions in Grand Junction may not be useful indicators of the direction of longer-range transport. Little Delores is on the Uncompahgre Plateau, and winds here are more likely to reflect the larger-scale transport directions for the region. This graph indicates that high PM_{10} at Grand Junction (Cluster 5) is associated with winds from the south-southeast to west-southwest at Little Delores. These directions point to dust sources in southeast Utah and northeastern Arizona. This is further evidence that dust from these areas may make a significant contribution to PM_{10} measured in Grand Junction during blowing dust events.

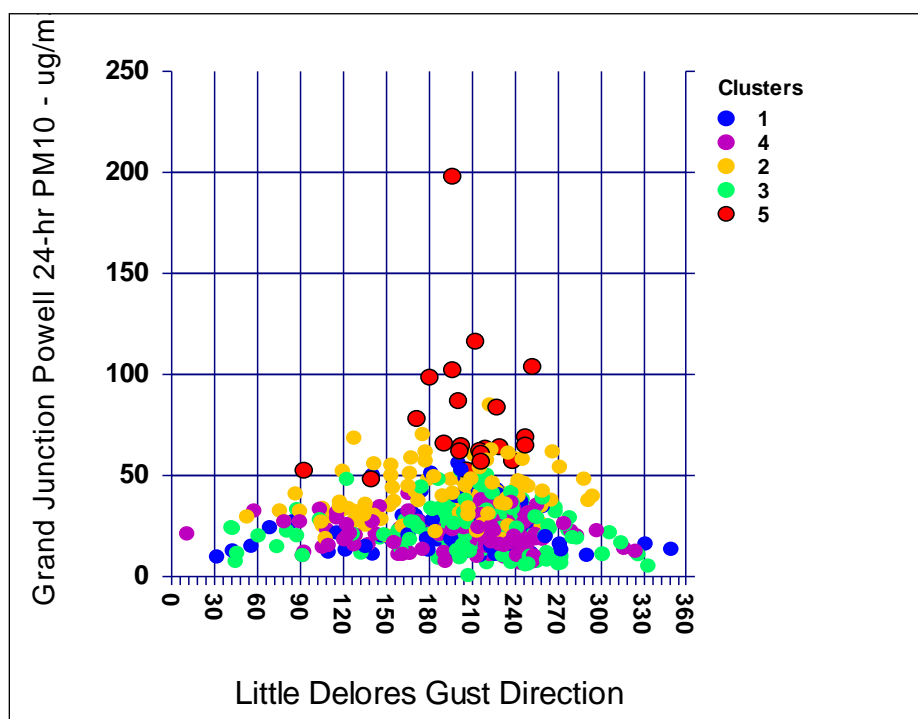


Figure A-24. Grand Junction Powell 24-hour PM_{10} concentrations versus peak gust wind directions at the Little Delores RAWs weather station, by cluster.

Figure A-25 presents monthly percentiles for Grand Junction gust speeds. Wind gusts generally considered to be high enough for significant blowing dusts (40 mph or higher) are within the upper 5 to 15 percent during each month of the year. Consequently, these events can be viewed as exceptional rather than normal. Gusts in this category can occur any month of the year, but are most likely in March, April, May and October. Figure A-4 shows that in Grand Junction these are typically among the wettest months of the year. It is in drier years, therefore, that blowing dust may be most prevalent during the spring and fall months. January, February, and June are typically very dry, and might be expected to have a significant proportion of blowing dust events.

Figures A-26 and A-27 show histograms for Grand Junction and Hopi wind gusts, respectively. The 95th

percentile gust speed for Grand Junction is 43 mph. For Hopi it is 41 mph. For both sites, it is clear that gusts in the range that is associated with blowing dust are the exception rather than the rule. Cluster analysis also shows that the blowing dust events represent only 4% of the PM₁₀ sample days (from Table A-2, Cluster 5 had 24 cases out of a total of 546). The weight of evidence presented in this document clearly suggests that source regions in Arizona and Utah can have a significant impact on PM₁₀ concentrations in Grand Junction during blowing dust events and that these events occur when dry soils are affected by winds of exceptional strength. Control of these sources, which are outside of Colorado, may not be reasonably achievable or possible.

The precipitation climatology for the Four Corners area indicates that the area can be susceptible to blowing dust when winds are high. Landform imagery shows that northeastern Arizona and southeastern Utah in particular have experienced a long-term pattern of wind erosion and blowing dust when winds have been southwesterly and blowing into western and southern Colorado. Back trajectories, case studies, satellite imagery, and statistical analyses have also shown that northeastern Arizona and southeastern Utah are a significant source for blowing dust transported into Colorado. Elevated PM₁₀ in Grand Junction during windstorms is generally associated with wind gusts of 40 mph or higher at Grand Junction and Hopi in northeastern Arizona and southwesterly flow in Grand Junction. Elevated PM₁₀ in Grand Junction is generally associated with 30-day precipitation totals of less than 1.00 inches at Grand Junction and less than 0.50 inches at Hopi.

Reference:

Orgill, M.M., Sehmel, G.A., 1976. Frequency and diurnal variation of dust storms in the contiguous USA. **Atmospheric Environment** 10, 813-825

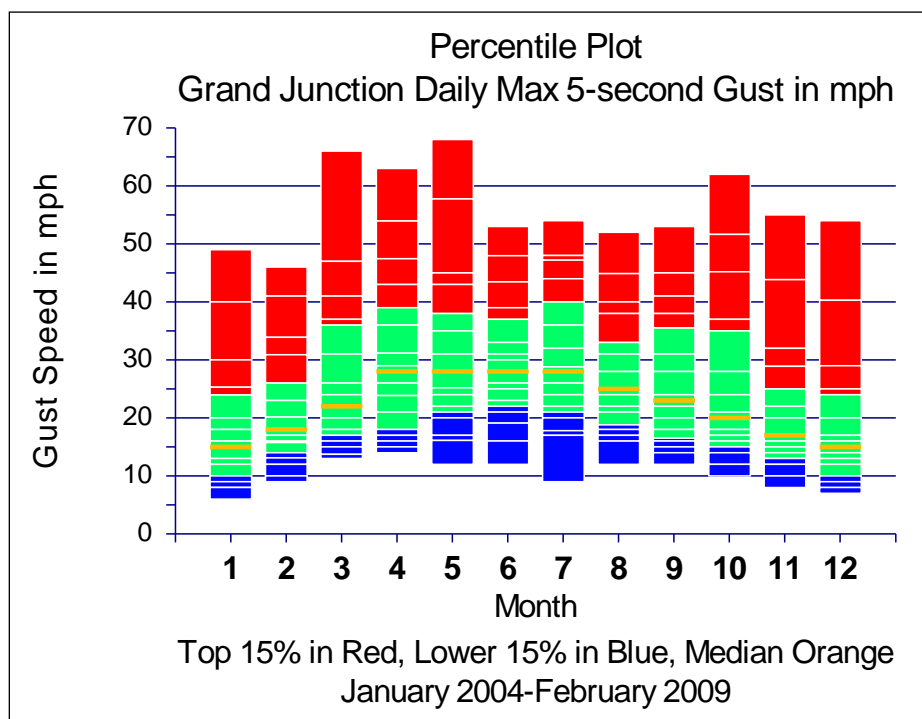


Figure A-25. Percentile plot of Grand Junction daily maximum 5-second gust speed in miles per hour showing that gusts of 40 mph or greater always occur within the top 15 percentile speeds for each month of the year.

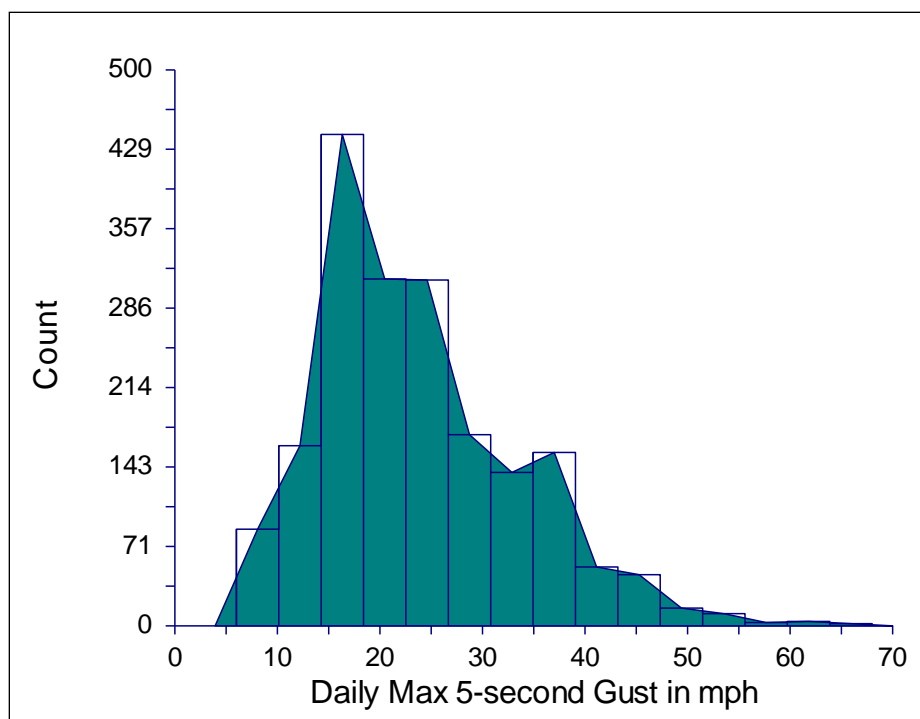


Figure A-26. Histogram of daily maximum 5-second wind gusts at Grand Junction based on January 2004 – February 2009.

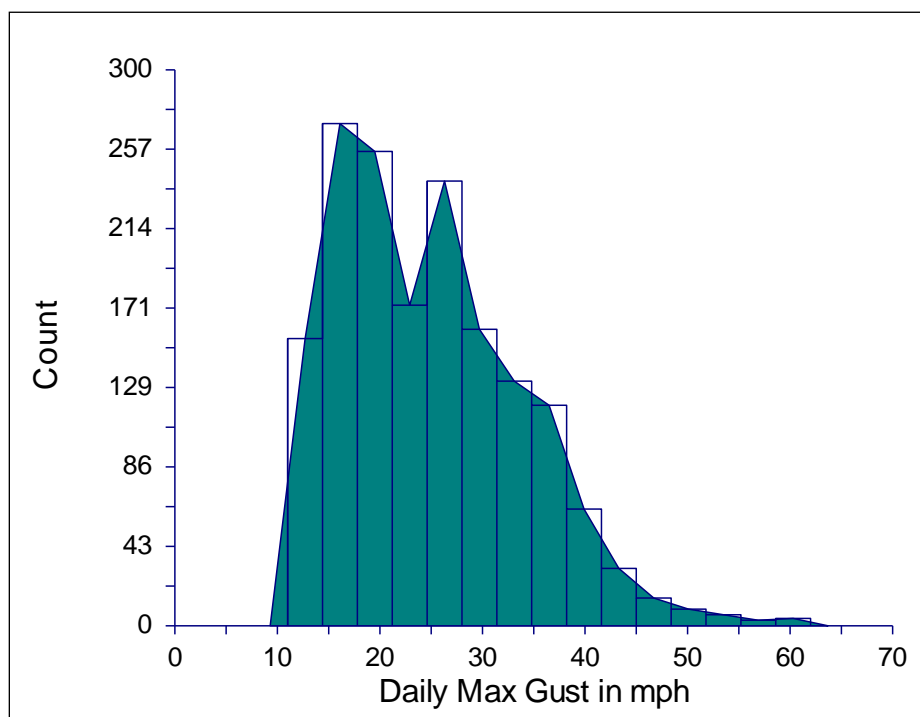
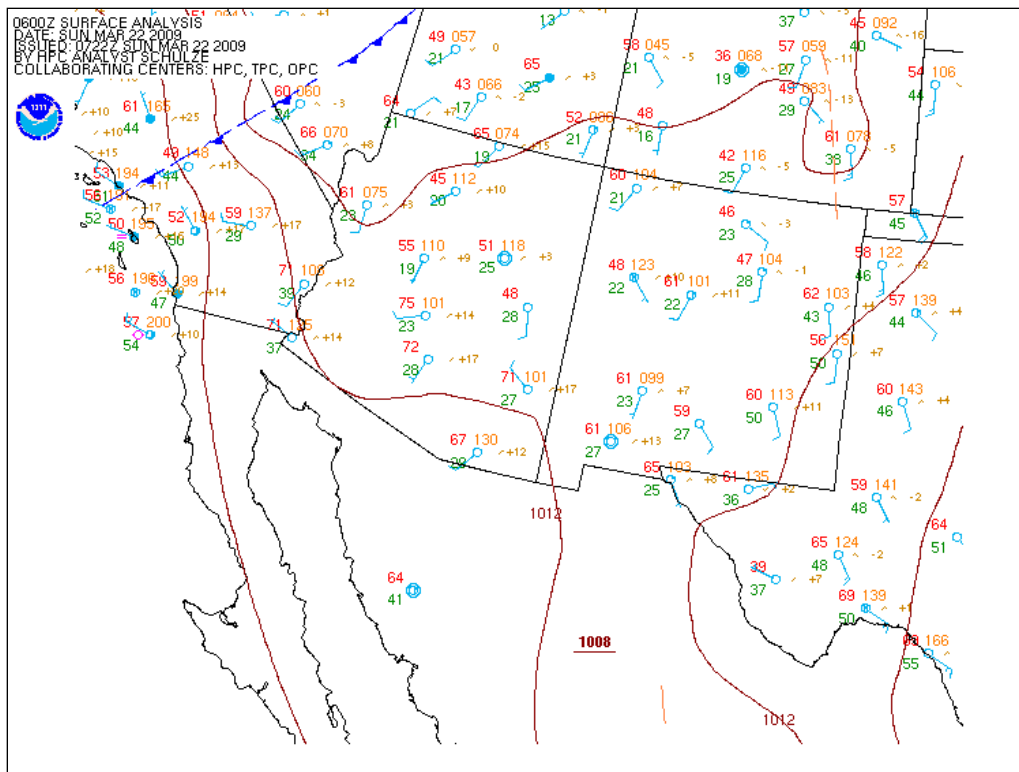


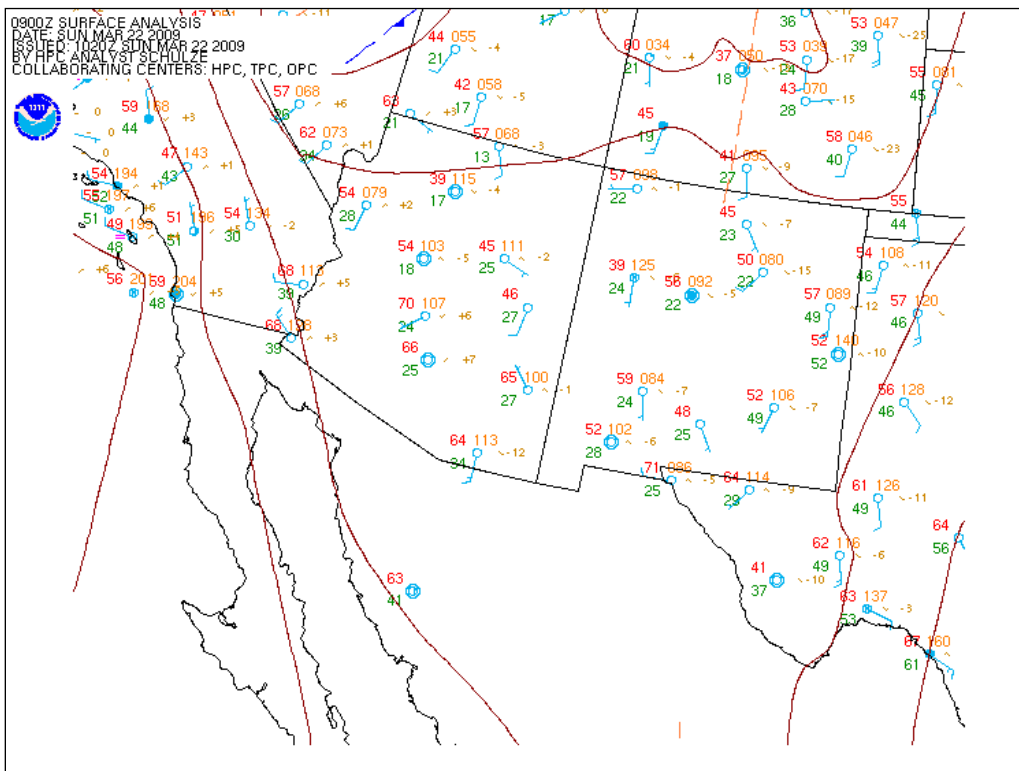
Figure A-27. Histogram of daily maximum 5-second wind gusts at Hopi based on January 2004 – February 2009.

Attachment B - Southwest Surface Analysis:

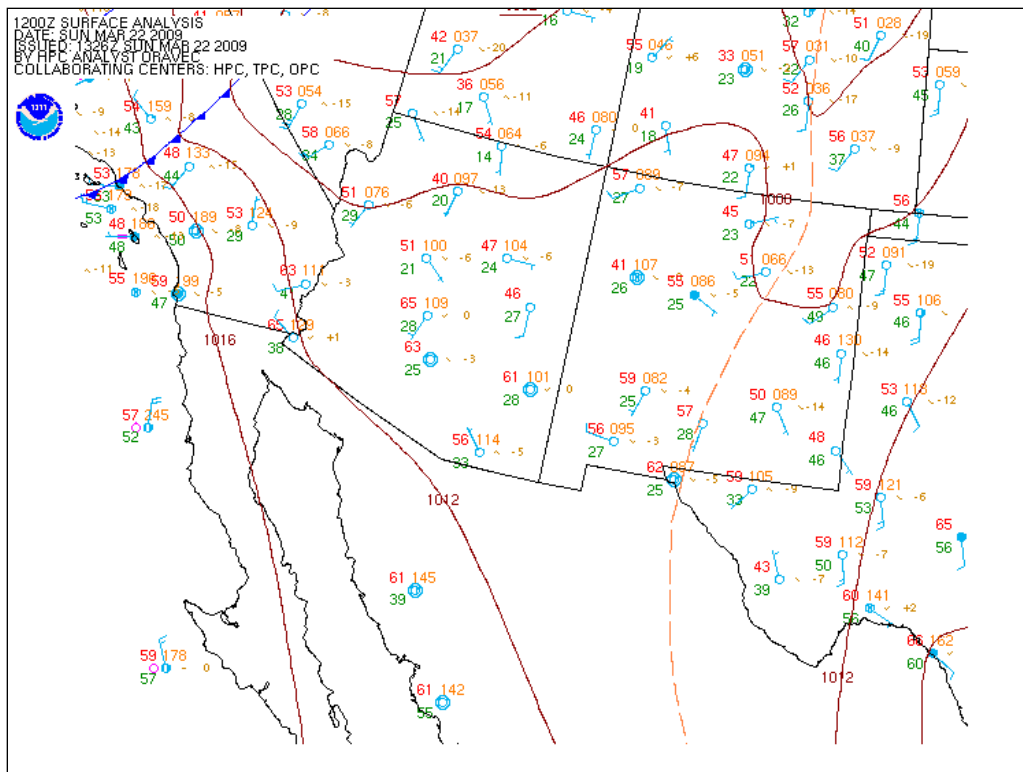
0600Z March 22, 2009 (11 PM MST March 21, 2009)
through 0600Z March 23, 2009 (11 PM MST March 21, 2009).



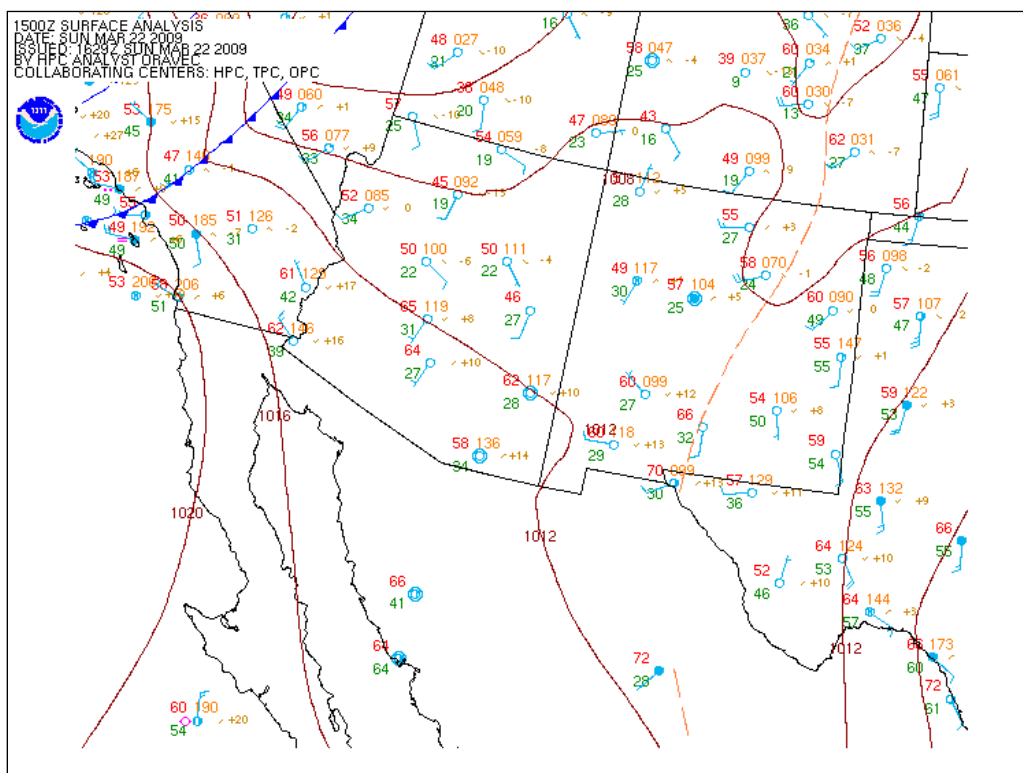
Southwest Surface analysis for 0600Z March 22, 2009, or 11 PM MST March 21, 2009
<http://nomads.ncdc.noaa.gov/ncdp/NCEP>.



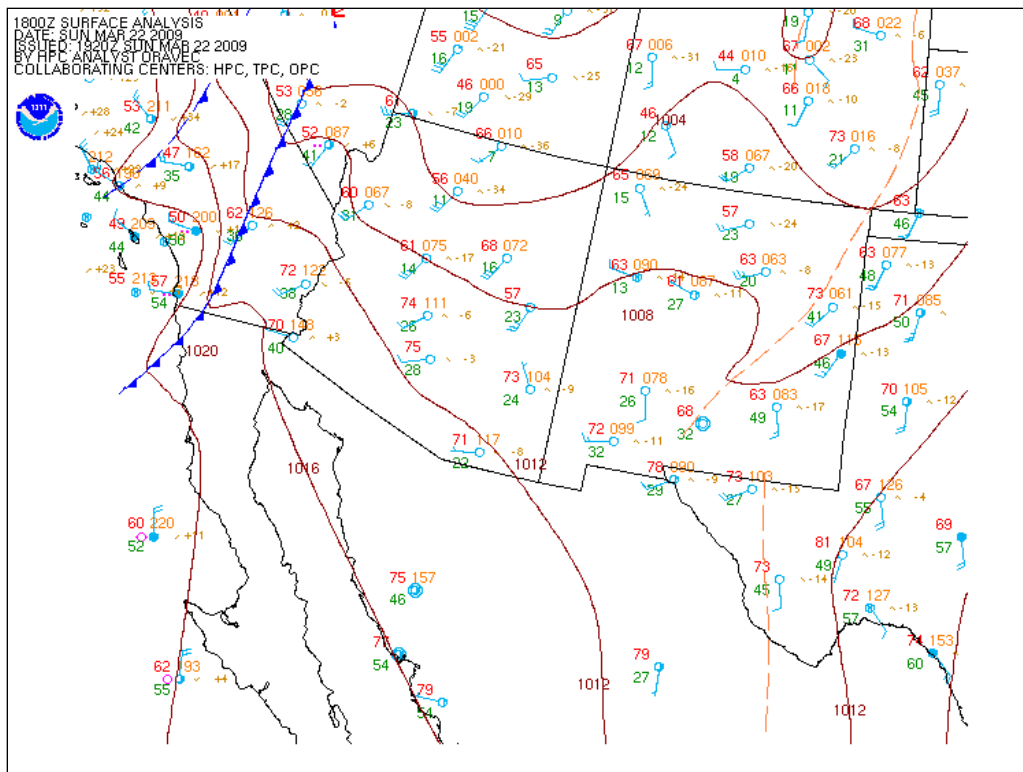
Southwest Surface analysis for 0900Z March 22, 2009, or 2 AM MST March 22, 2009
<http://nomads.ncdc.noaa.gov/ncdp/NCEP>.



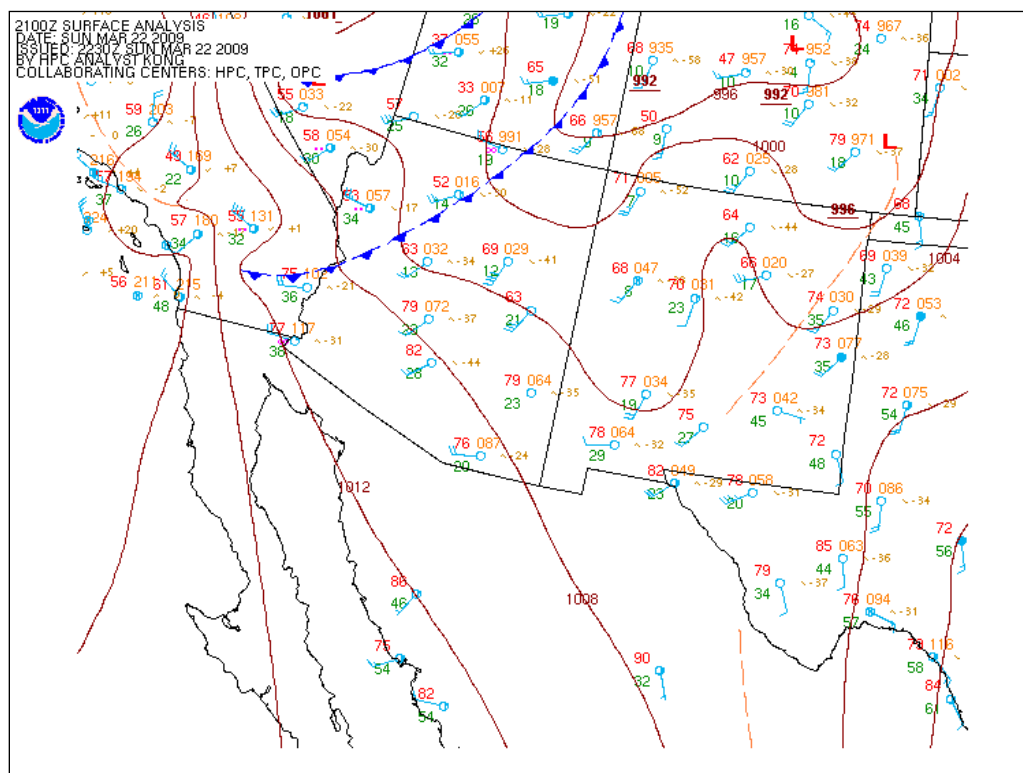
Southwest Surface analysis for 1200Z March 22, 2009, or 5 AM MST March 22, 2009
<http://nomads.ncdc.noaa.gov/ncdp/NCEP>.



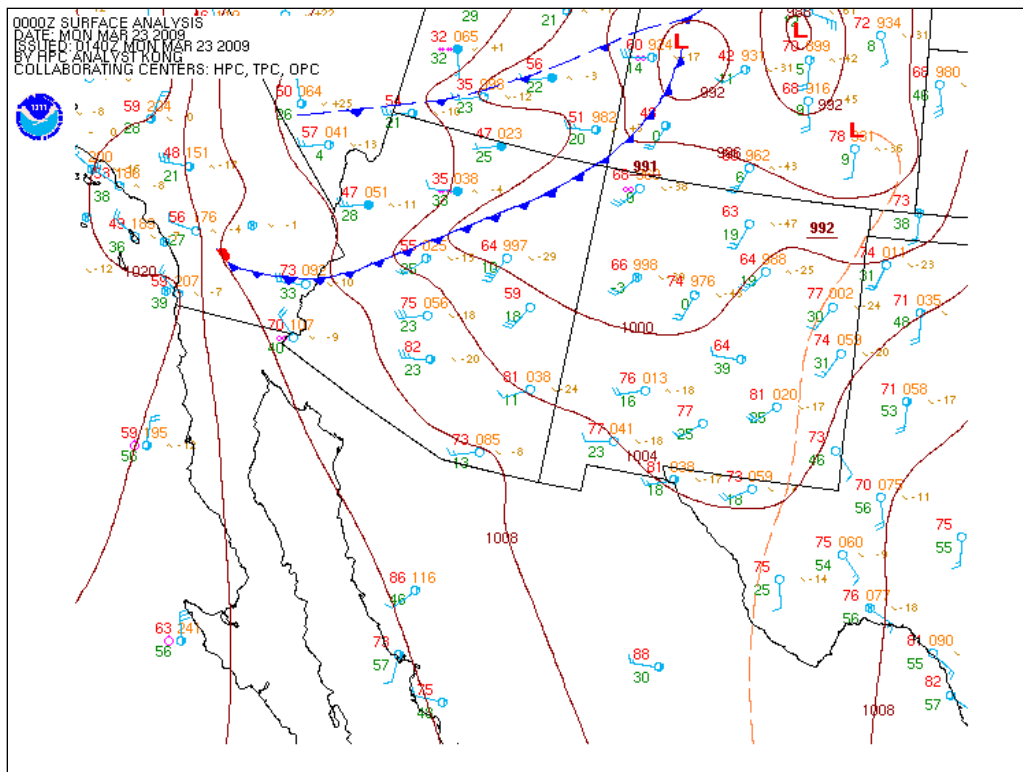
Southwest Surface analysis for 1500Z March 22, 2009, or 8 AM MST March 22, 2009
<http://nomads.ncdc.noaa.gov/ncdp/NCEP>.



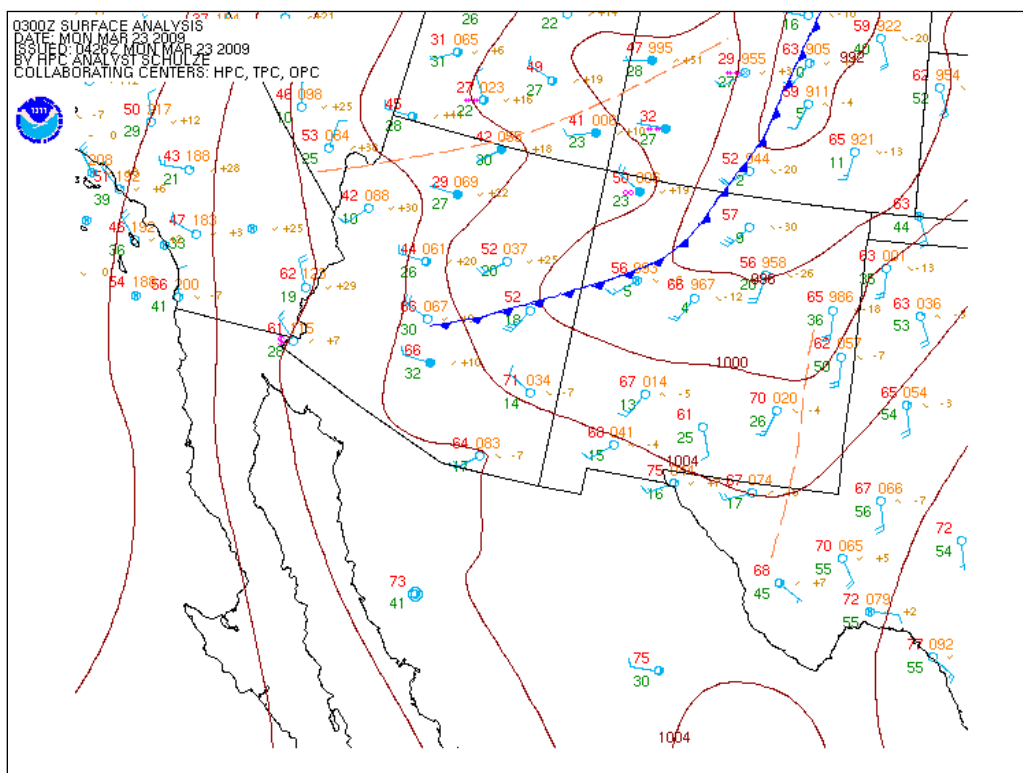
Southwest Surface analysis for 1800Z March 22, 2009, or 11 AM MST March 22, 2009
<http://nomads.ncdc.noaa.gov/ncdp/NCEP>.



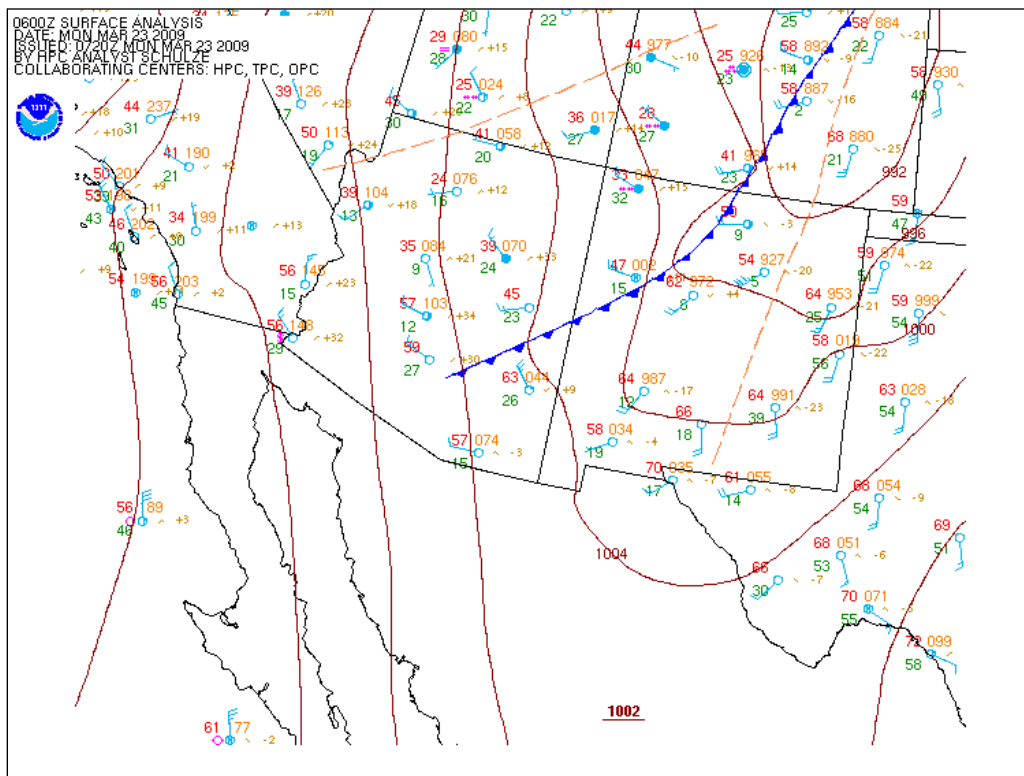
Southwest Surface analysis for 2100Z March 22, 2009, or 2PM MST March 22, 2009
<http://nomads.ncdc.noaa.gov/ncdp/NCEP>.



Southwest Surface analysis for 0000Z March 23, 2009, or 5PM MST March 22, 2009
<http://nomads.ncdc.noaa.gov/ncdp/NCEP>.



Southwest Surface analysis for 0300Z March 23, 2009, or 8PM MST March 22, 2009
<http://nomads.ncdc.noaa.gov/ncdp/NCEP>.

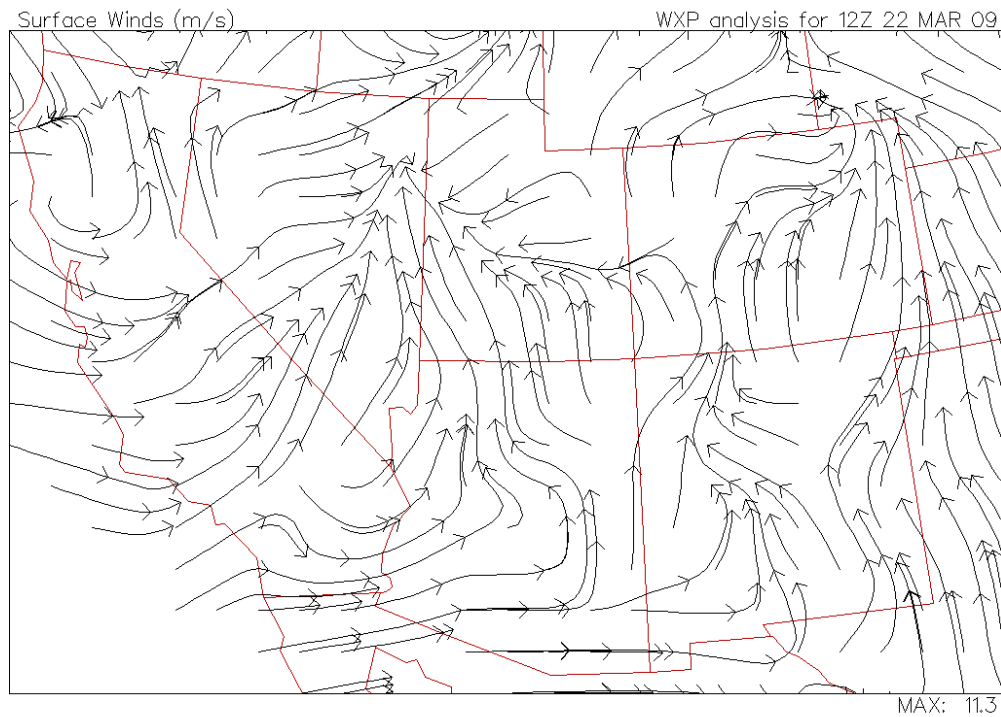


Southwest Surface analysis for 0600Z March 23, 2009, or *11PM MST March 22, 2009*
<http://nomads.ncdc.noaa.gov/ncep/NCEP>.

Attachment C - Hourly Surface Streamlines:

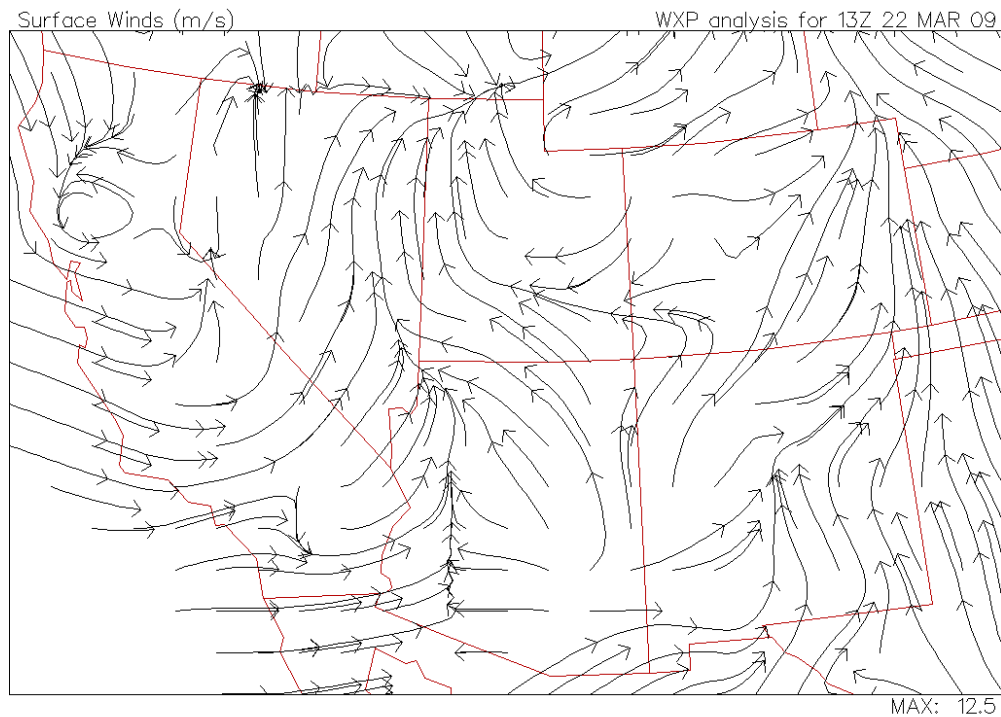
12 Z March 22, 2009 (5 AM MST March 22, 2009)
through 06 Z March 23, 2009 (11 PM MST March 22, 2009).

▼ Plymouth State Weather Center ▼



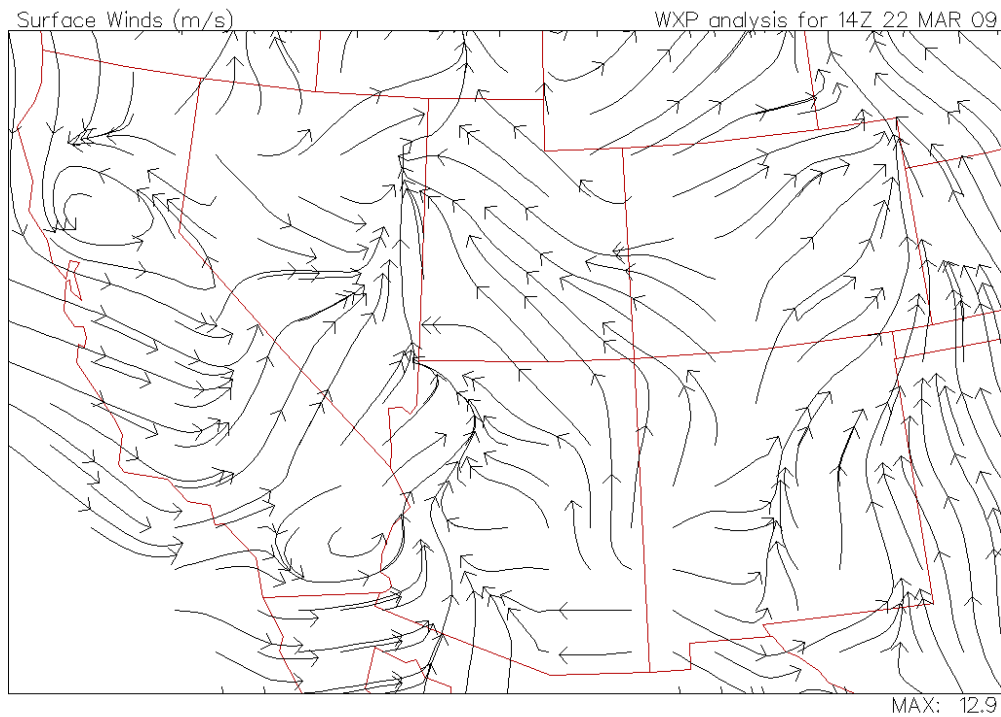
Southwest Streamline Analysis for 1200Z March 22, 2009, or 5 AM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).

▼ Plymouth State Weather Center ▼



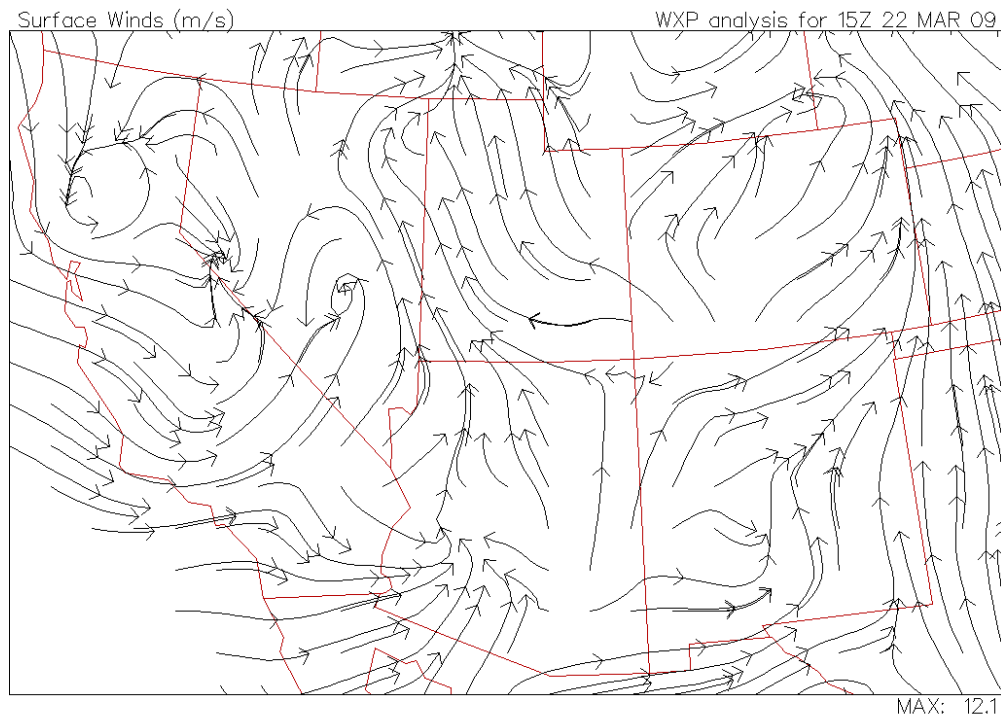
Southwest Streamline Analysis for 1300Z March 22, 2009, or 6 AM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).

▼ Plymouth State Weather Center ▼



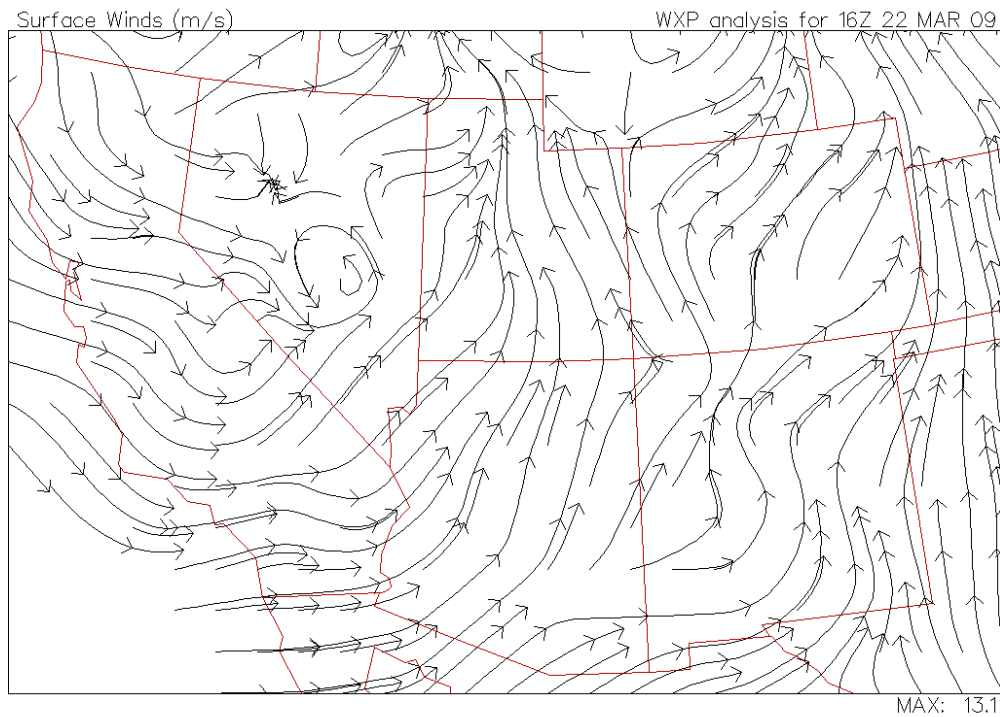
Southwest Streamline Analysis for 1400Z March 22, 2009, or 7 AM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).

▼ Plymouth State Weather Center ▼



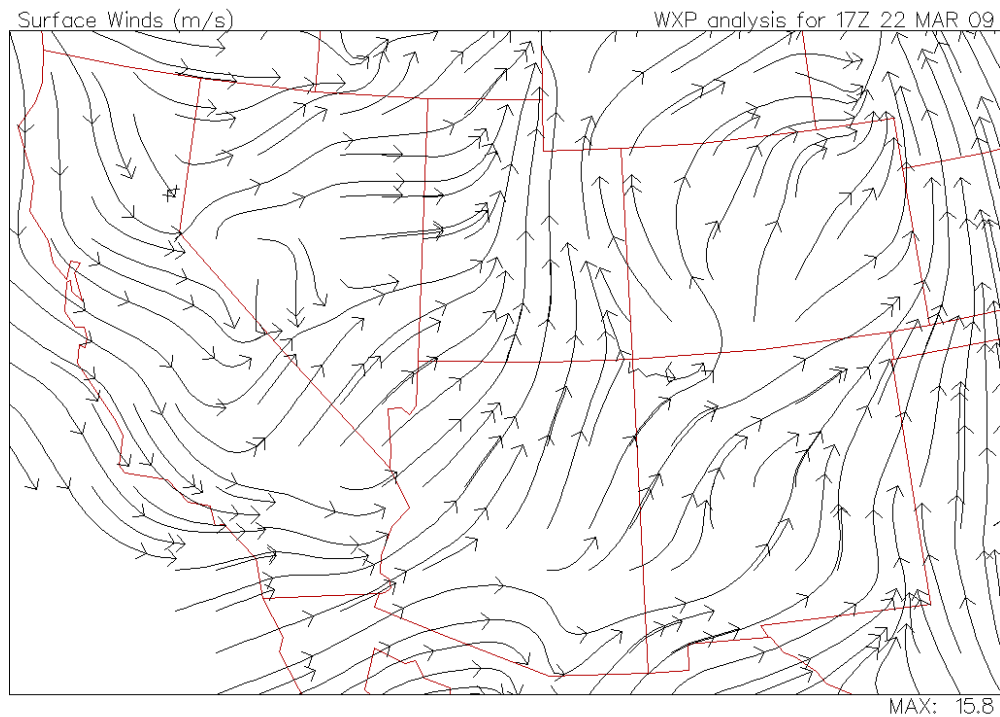
Southwest Streamline Analysis for 1500Z March 22, 2009, or 8 AM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).

▼ Plymouth State Weather Center ▼



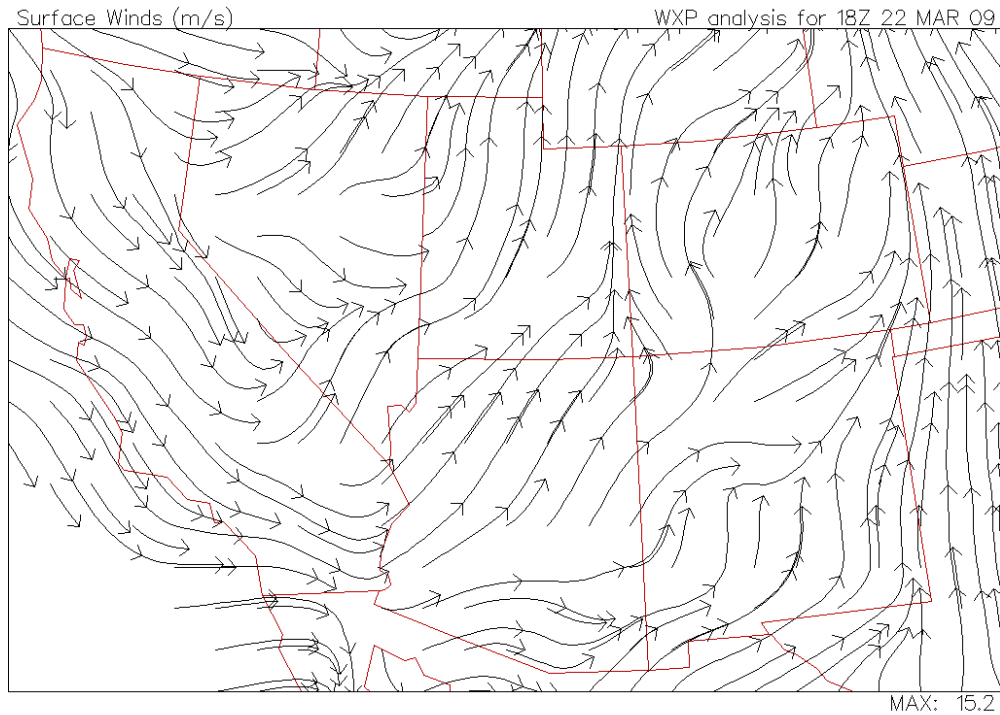
Southwest Streamline Analysis for 1600Z March 22, 2009, or 9 AM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).

▼ Plymouth State Weather Center ▼



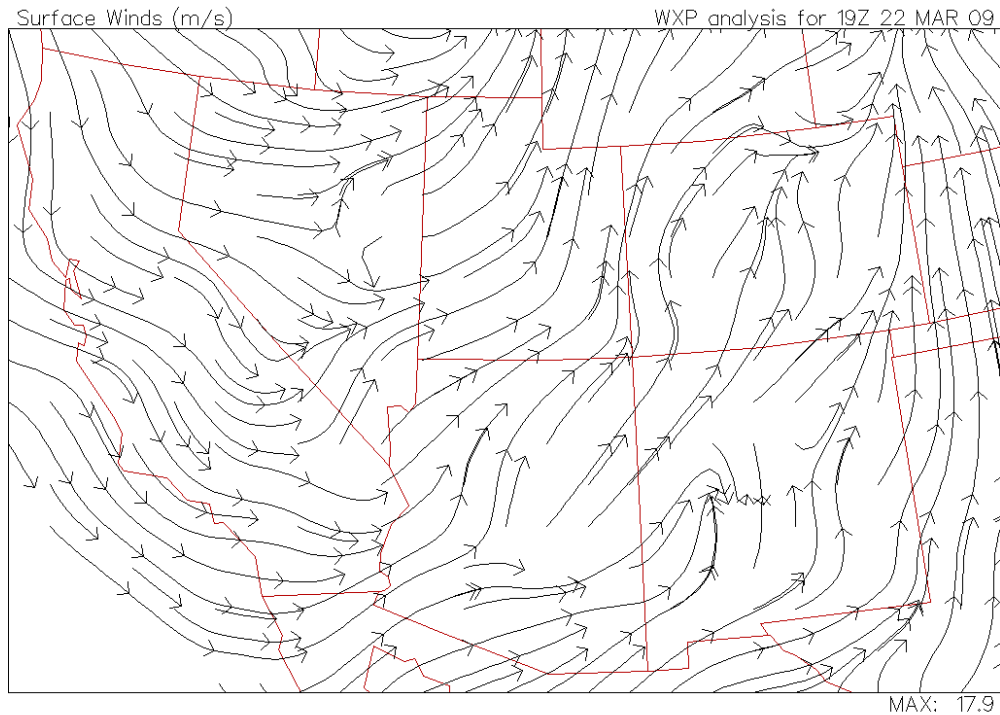
Southwest Streamline Analysis for 1700Z March 22, 2009, or 10 AM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).

▼ Plymouth State Weather Center ▼

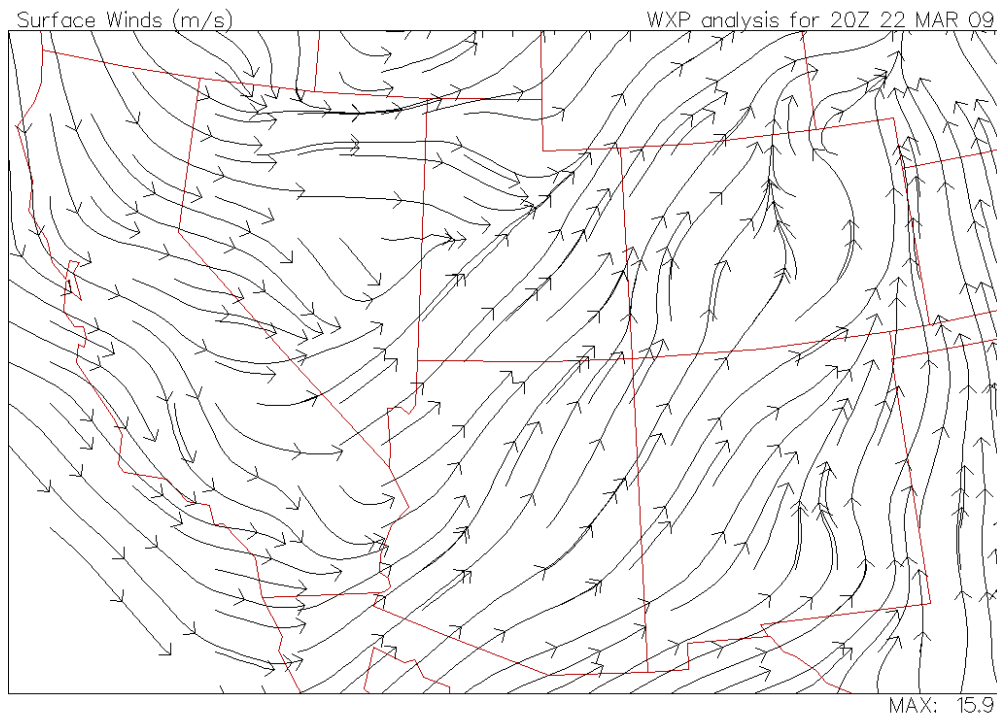


Southwest Streamline Analysis for 1800Z March 22, 2009, or 11 AM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).

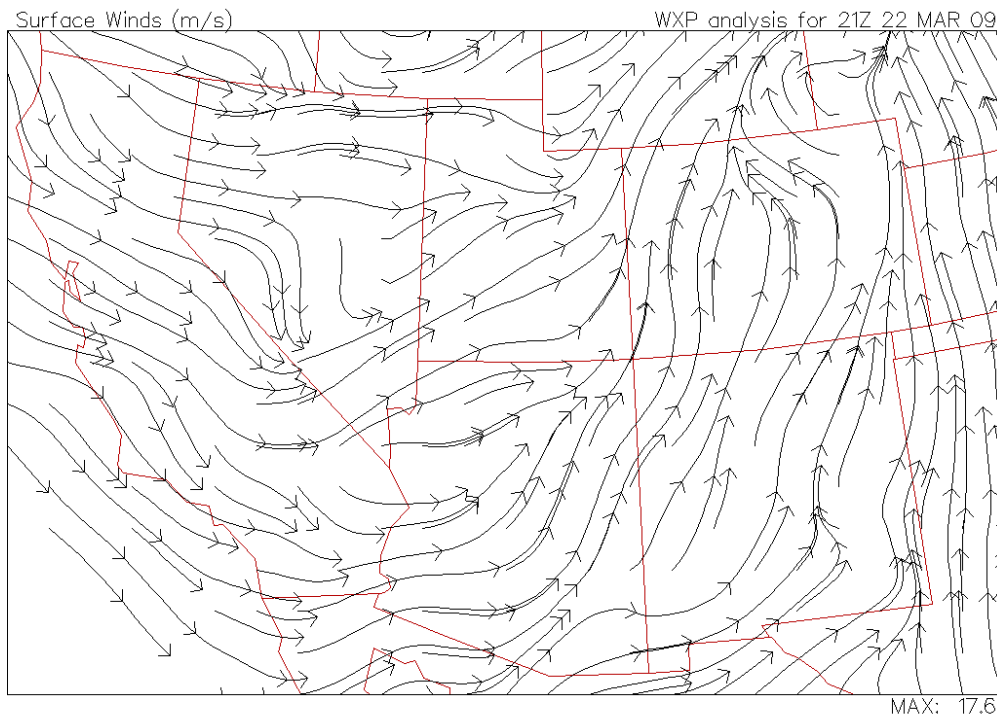
▼ Plymouth State Weather Center ▼



Southwest Streamline Analysis for 1900Z March 22, 2009, or 12 PM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).

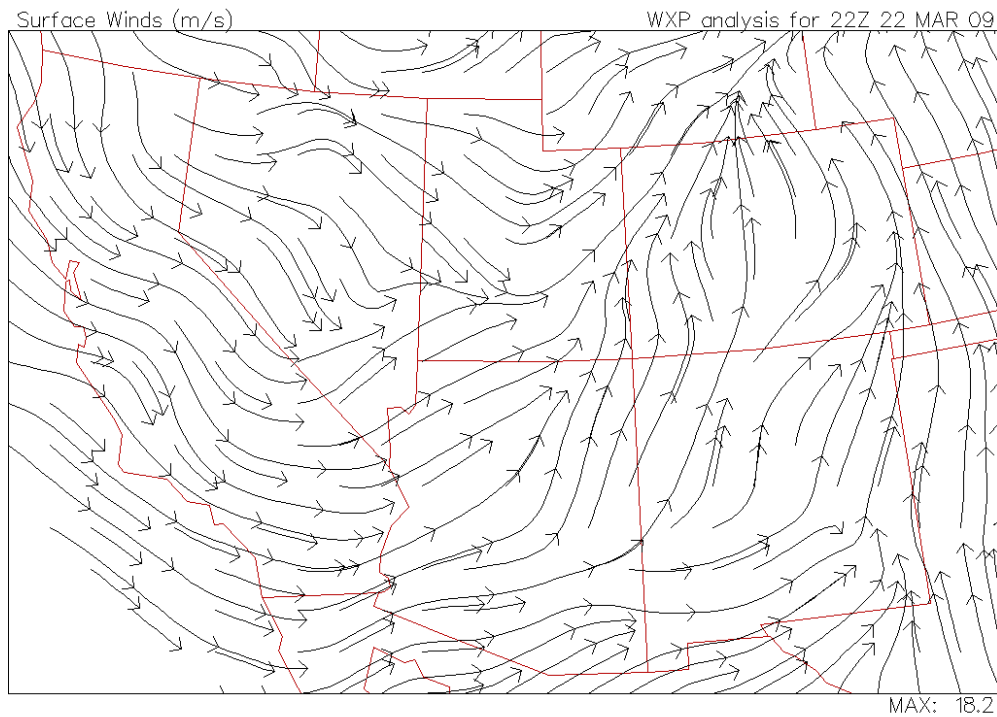


Southwest Streamline Analysis for 2000Z March 22, 2009, or 13 PM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).



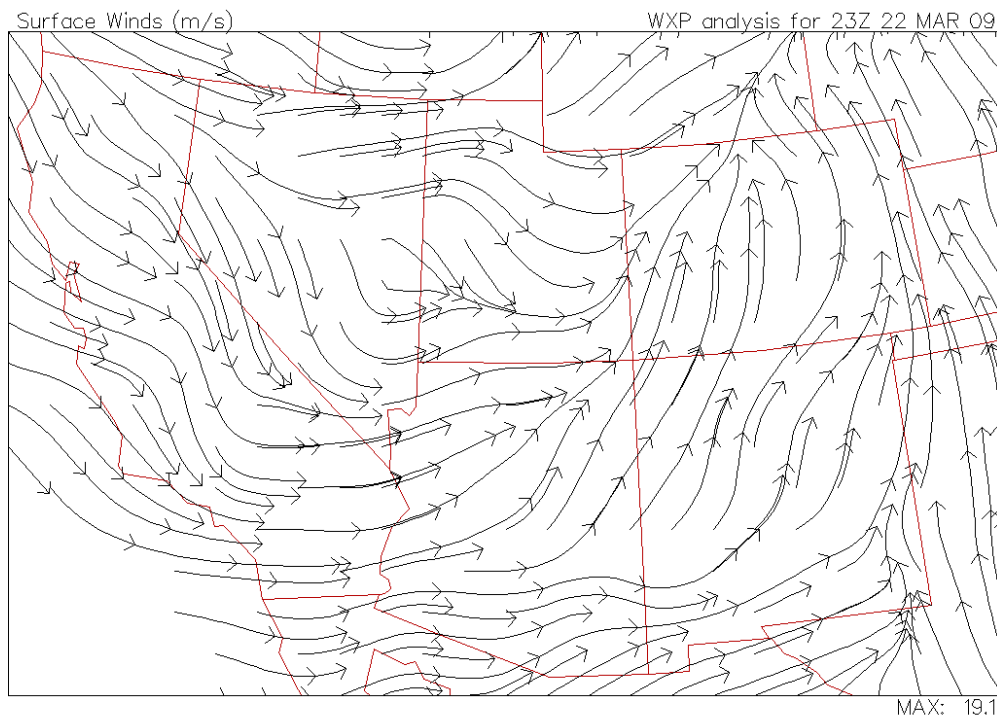
Southwest Streamline Analysis for 2100Z March 22, 2009, or 2 PM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).

▼ Plymouth State Weather Center ▼



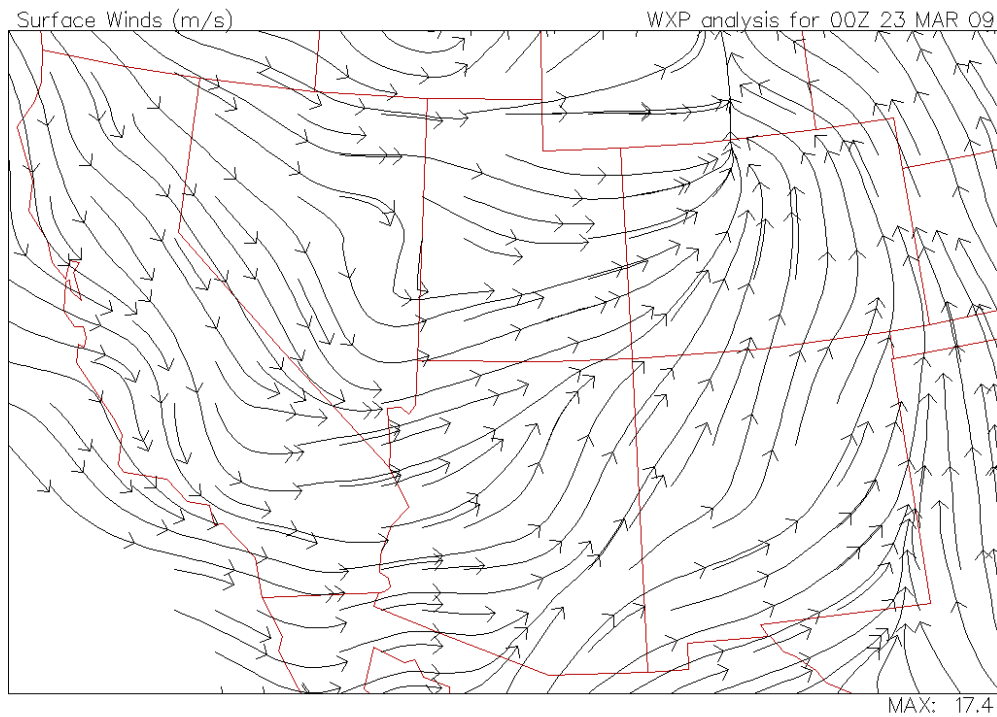
Southwest Streamline Analysis for 2200Z March 22, 2009, or 3 PM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).

▼ Plymouth State Weather Center ▼



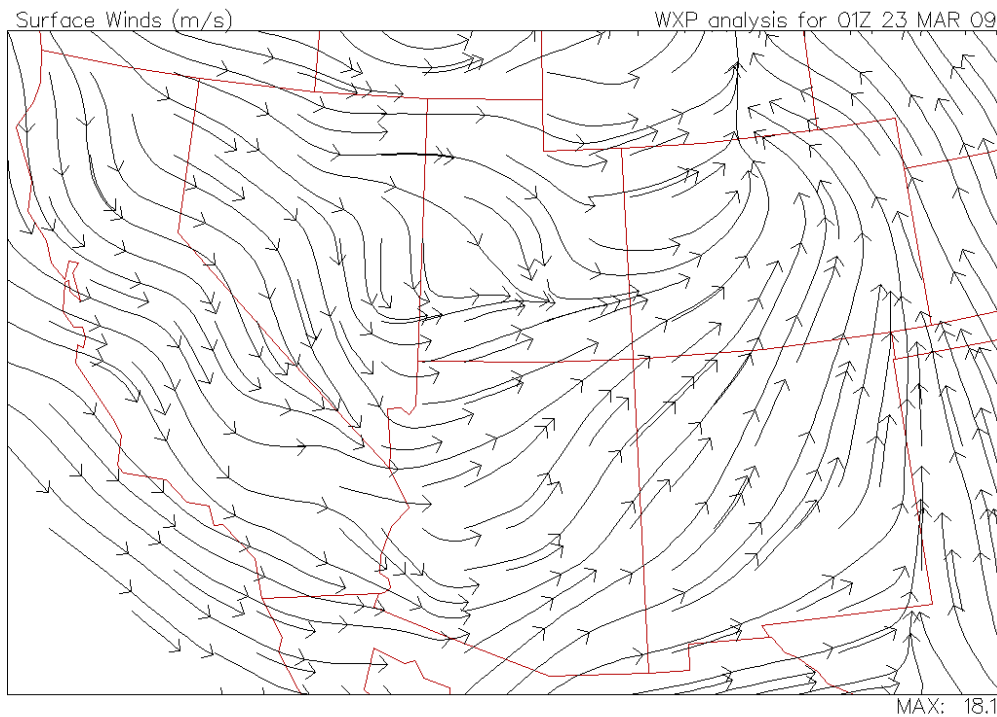
Southwest Streamline Analysis for 2300Z March 22, 2009, or 4 PM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).

▼ Plymouth State Weather Center ▼

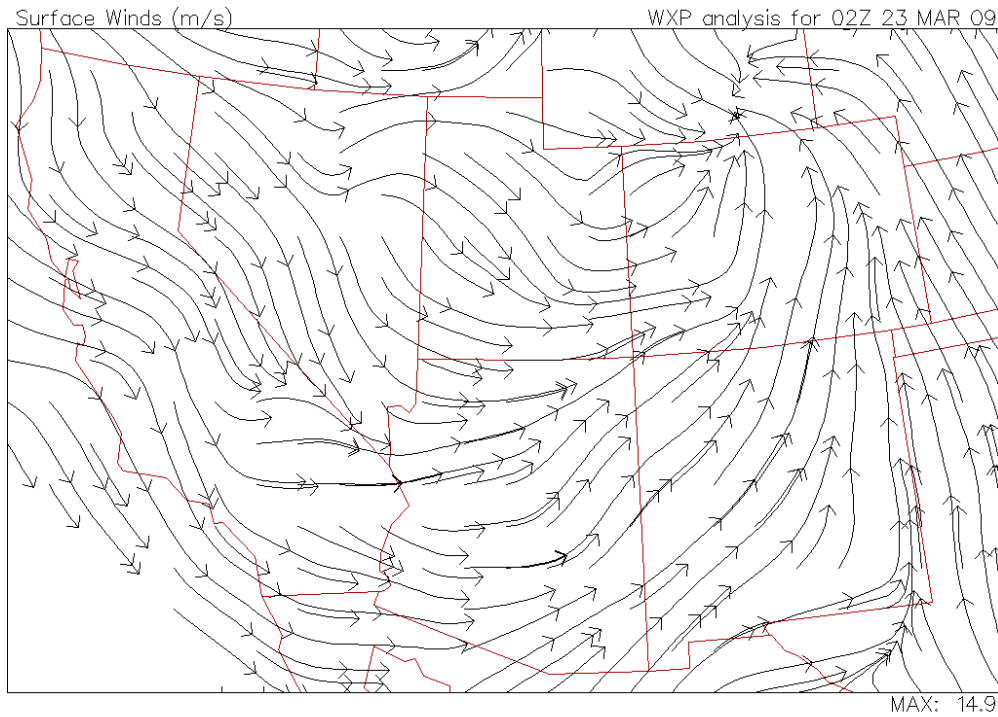


Southwest Streamline Analysis for 0000Z March 23, 2009, or 5 PM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).

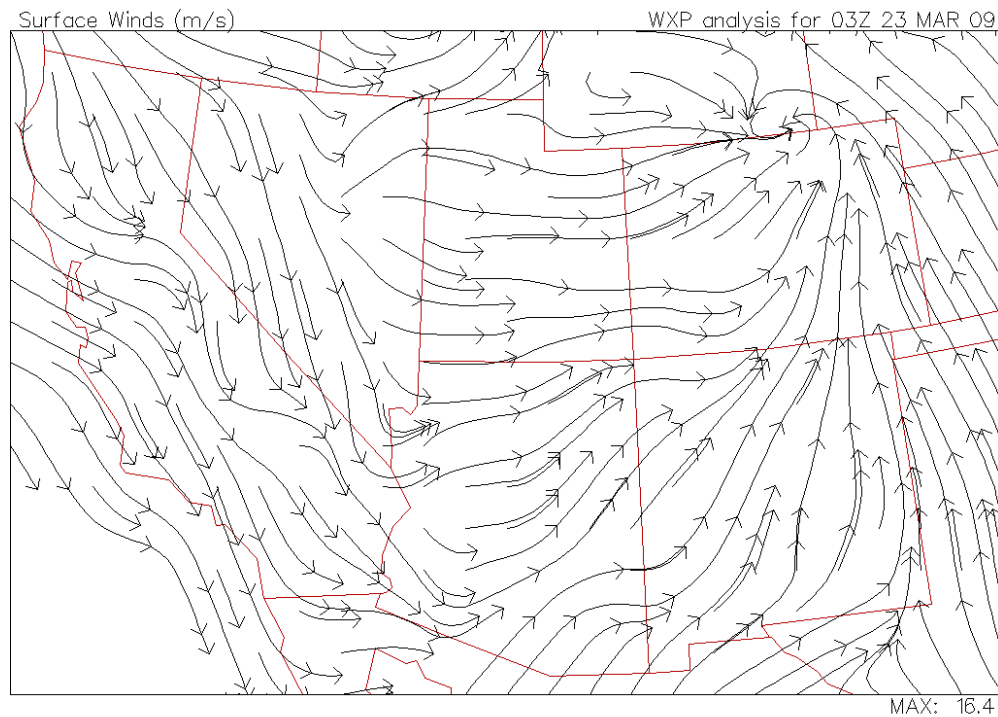
▼ Plymouth State Weather Center ▼



Southwest Streamline Analysis for 0100Z March 23, 2009, or 6 PM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).

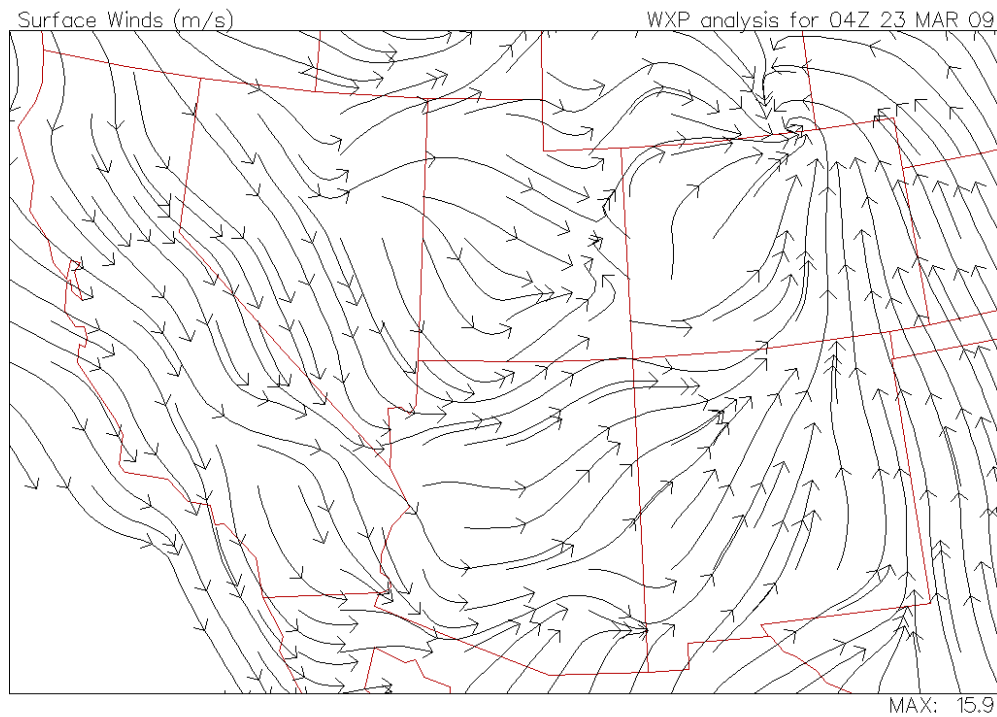


Southwest Streamline Analysis for 0200Z March 23, 2009, or 7 PM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).



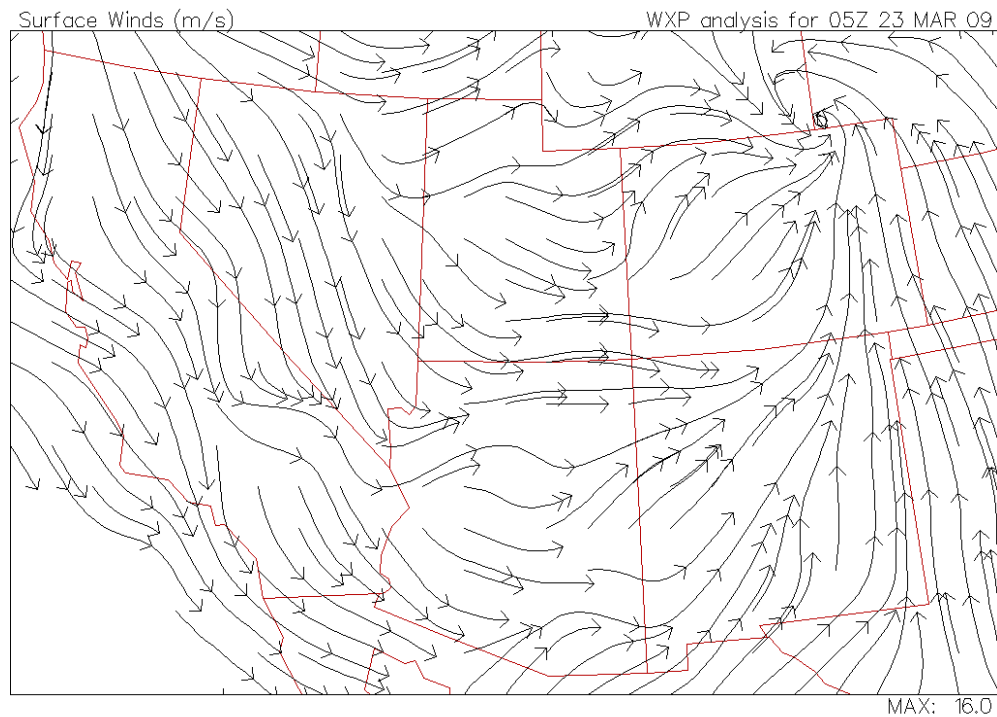
Southwest Streamline Analysis for 0300Z March 23, 2009, or 8 PM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).

▼ Plymouth State Weather Center ▼

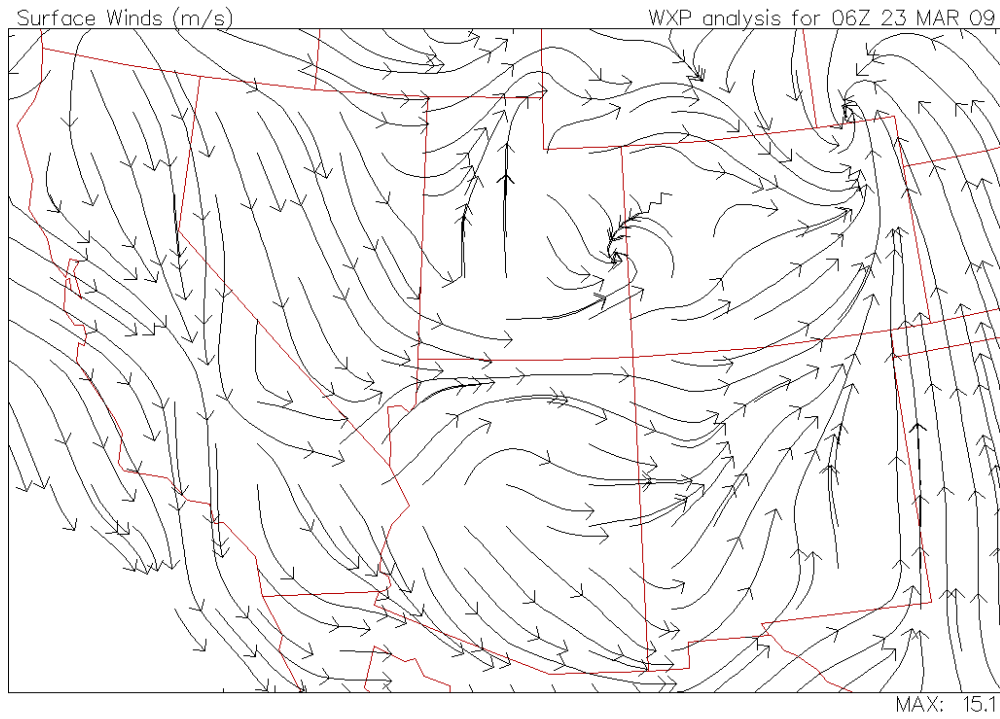


Southwest Streamline Analysis for 0400Z March 23, 2009, or 9 PM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).

▼ Plymouth State Weather Center ▼



Southwest Streamline Analysis for 0500Z March 23, 2009, or 10 PM MST March 22, 2009
(<http://vortex.plymouth.edu/u-make.html>).



Southwest Streamline Analysis for 0600Z March 23, 2009, or *11 PM MST March 22, 2009*
(<http://vortex.plymouth.edu/u-make.html>).

Attachment D - Weather Warnings and Advisories from the National Weather Service Forecast Offices in Grand Junction, Colorado, Flagstaff, Arizona, and Albuquerque, New Mexico for March 22, 2009.

Weather Warnings and Advisories from <http://has.ncdc.noaa.gov>.

NWS SRRS PRODUCTS FOR:
2009032200 to 2009032400

Flagstaff Arizona National Weather Service Forecast Office

WWUS75 KFGZ 220450

NPWFGZ

URGENT - WEATHER MESSAGE

NATIONAL WEATHER SERVICE FLAGSTAFF AZ

950 PM MST SAT MAR 21 2009

AZZ004>011-015>018-037>039-221300-

/O.CON.KFGZ.WI.Y.0005.090322T1600Z-090323T0600Z/

KAIBAB PLATEAU-MARBLE AND GLEN CANYONS-GRAND CANYON COUNTRY-

COCONINO PLATEAU-YAVAPAI COUNTY MOUNTAINS-

NORTHEAST PLATEAUS AND MESAS HWY 264 NORTHWARD-CHINLE VALLEY-

CHUSKA MOUNTAINS AND DEFIANCE PLATEAU-WESTERN MOGOLLON RIM-

EASTERN MOGOLLON RIM-WHITE MOUNTAINS-NORTHERN GILA COUNTY-

YAVAPAI COUNTY VALLEYS AND BASINS-OAK CREEK AND SYCAMORE CANYONS-

BLACK MESA AREA-

INCLUDING THE CITIES OF...JACOB LAKE...FREDONIA...PAGE...

LEES FERRY...GRAND CANYON VILLAGE...SUPAI...NORTH RIM...VALLE...

PRESCOTT...SELIGMAN...ASH FORK...KEAMS CANYON...KAIBITO...

CANYON DE CHELLY...CHINLE...KAYENTA...WINDOW ROCK...GANADO...

FLAGSTAFF...WILLIAMS...MUNDS PARK...HEBER...HAPPY JACK...

FOREST LAKES...SHOW LOW...GREER...PINETOP...PAYSON...STRAWBERRY...

YOUNG...COTTONWOOD...CAMP VERDE...CORDES JUNCTION...BAGDAD...

SEDONA...NAVAJO N.M.

950 PM MST SAT MAR 21 2009

...WIND ADVISORY REMAINS IN EFFECT FROM 9 AM TO 11 PM MST
SUNDAY...

A WIND ADVISORY REMAINS IN EFFECT FROM 9 AM TO 11 PM MST SUNDAY.

A STRONG LOW PRESSURE SYSTEM MOVING ACROSS THE GREAT BASIN SUNDAY WILL

BRING STRONG WINDS TO NORTHERN ARIZONA. BEGINNING LATE SUNDAY

MORNING...SOUTHWEST WINDS WILL INCREASE TO 30 TO 40 MPH WITH

GUSTS FROM 45 TO 55 MPH OVER MUCH OF THE AREA. THESE STRONG WINDS ARE

ANTICIPATED TO CONTINUE INTO THE LATE EVENING HOURS AS THE STORM

SYSTEM MOVES THROUGH THE AREA.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

A WIND ADVISORY MEANS THAT SUSTAINED WINDS OF 30 TO 39 MPH...OR

GUSTS FROM 40 TO 57 MPH...ARE EXPECTED. WINDS THIS STRONG CAN

MAKE DRIVING DIFFICULT...ESPECIALLY FOR HIGH PROFILE VEHICLES.

CONSIDER SECURING LOOSE BELONGINGS ON YOUR PROPERTY. ADDITIONAL

WEATHER INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.

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AZZ012>014-040-221300-

/O.CON.KFGZ.HW.A.0001.090322T1600Z-090323T0600Z/

LITTLE COLORADO RIVER VALLEY IN COCONINO COUNTY-

LITTLE COLORADO RIVER VALLEY IN NAVAJO COUNTY-

LITTLE COLORADO RIVER VALLEY IN APACHE COUNTY-

NORTHEAST PLATEAUS AND MESAS SOUTH OF HWY 264-

INCLUDING THE CITIES OF...WUPATKI N.M....TUBA CITY...WINSLOW...

HOLBROOK...SNOWFLAKE...ST. JOHNS...SPRINGERVILLE...DILKON...

KYKOTSMOVI

950 PM MST SAT MAR 21 2009

...HIGH WIND WATCH REMAINS IN EFFECT FROM 9 AM MST SUNDAY THROUGH

SUNDAY EVENING...

A HIGH WIND WATCH REMAINS IN EFFECT FROM 9 AM MST SUNDAY THROUGH SUNDAY EVENING.

A STRONG LOW PRESSURE SYSTEM MOVING ACROSS THE GREAT BASIN SUNDAY WILL BRING VERY STRONG WINDS TO PORTIONS OF NORTHERN ARIZONA.

BEGINNING LATE SUNDAY MORNING...SOUTHWEST WINDS WILL INCREASE TO 40 TO 50 MPH WITH GUSTS UP TO 65 MPH OVER THE LITTLE COLORADO RIVER VALLEY AND ADJACENT AREAS. EXPECT WIND SPEEDS TO DIMINISH SUNDAY EVENING AS THE SYSTEM MOVES EASTWARD.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

A HIGH WIND WATCH MEANS THERE IS THE POTENTIAL FOR A HAZARDOUS HIGH WIND EVENT...WITH SUSTAINED WINDS GREATER THAN 40 MPH...OR GUSTS GREATER THAN 58 MPH. MONITOR THE LATEST FORECASTS AND WARNINGS FOR UPDATES ON THIS SITUATION. ADDITIONAL WEATHER INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.

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WWUS75 KFGZ 220450

NPWFGZ

URGENT - WEATHER MESSAGE

NATIONAL WEATHER SERVICE FLAGSTAFF AZ

950 PM MST SAT MAR 21 2009

AZZ004>011-015>018-037>039-221300-

/O.CON.KFGZ.WI.Y.0005.090322T1600Z-090323T0600Z/

KAIBAB PLATEAU-MARBLE AND GLEN CANYONS-GRAND CANYON COUNTRY-COCONINO PLATEAU-YAVAPAI COUNTY MOUNTAINS-

NORTHEAST PLATEAUS AND MESAS HWY 264 NORTHWARD-CHINLE VALLEY-

CHUSKA MOUNTAINS AND DEFIANCE PLATEAU-WESTERN MOGOLLON RIM-

EASTERN MOGOLLON RIM-WHITE MOUNTAINS-NORTHERN GILA COUNTY-

YAVAPAI COUNTY VALLEYS AND BASINS-OAK CREEK AND SYCAMORE CANYONS-BLACK MESA AREA-

INCLUDING THE CITIES OF...JACOB LAKE...FREDONIA...PAGE...

LEES FERRY...GRAND CANYON VILLAGE...SUPAI...NORTH RIM...VALLE...

PRESCOTT...SELIGMAN...ASH FORK...KEAMS CANYON...KAIBITO...

CANYON DE CHELLY...CHINLE...KAYENTA...WINDOW ROCK...GANADO...

FLAGSTAFF...WILLIAMS...MUNDS PARK...HEBER...HAPPY JACK...

FOREST LAKES...SHOW LOW...GREER...PINETOP...PAYSON...STRAWBERRY...

YOUNG...COTTONWOOD...CAMP VERDE...CORDES JUNCTION...BAGDAD...

SEDONA...NAVAJO N.M.

950 PM MST SAT MAR 21 2009

...WIND ADVISORY REMAINS IN EFFECT FROM 9 AM TO 11 PM MST

SUNDAY...

A WIND ADVISORY REMAINS IN EFFECT FROM 9 AM TO 11 PM MST SUNDAY.

A STRONG LOW PRESSURE SYSTEM MOVING ACROSS THE GREAT BASIN SUNDAY WILL BRING STRONG WINDS TO NORTHERN ARIZONA. BEGINNING LATE SUNDAY

MORNING...SOUTHWEST WINDS WILL INCREASE TO 30 TO 40 MPH WITH GUSTS FROM 45 TO 55 MPH OVER MUCH OF THE AREA. THESE STRONG WINDS ARE

ANTICIPATED TO CONTINUE INTO THE LATE EVENING HOURS AS THE STORM SYSTEM MOVES THROUGH THE AREA.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

A WIND ADVISORY MEANS THAT SUSTAINED WINDS OF 30 TO 39 MPH...OR GUSTS FROM 40 TO 57 MPH...ARE EXPECTED. WINDS THIS STRONG CAN

MAKE DRIVING DIFFICULT...ESPECIALLY FOR HIGH PROFILE VEHICLES. CONSIDER SECURING LOOSE BELONGINGS ON YOUR PROPERTY. ADDITIONAL WEATHER INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.

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AZZ012>014-040-221300-
/O.CON.KFGZ.HW.A.0001.090322T1600Z-090323T0600Z/
LITTLE COLORADO RIVER VALLEY IN COCONINO COUNTY-
LITTLE COLORADO RIVER VALLEY IN NAVAJO COUNTY-
LITTLE COLORADO RIVER VALLEY IN APACHE COUNTY-
NORTHEAST PLATEAUS AND MESAS SOUTH OF HWY 264-
INCLUDING THE CITIES OF...WUPATKI N.M....TUBA CITY...WINSLOW...
HOLBROOK...SNOWFLAKE...ST. JOHNS...SPRINGERVILLE...DILKON...
KYKOTSMOVI
950 PM MST SAT MAR 21 2009
...HIGH WIND WATCH REMAINS IN EFFECT FROM 9 AM MST SUNDAY THROUGH
SUNDAY EVENING...
A HIGH WIND WATCH REMAINS IN EFFECT FROM 9 AM MST SUNDAY THROUGH
SUNDAY EVENING.
A STRONG LOW PRESSURE SYSTEM MOVING ACROSS THE GREAT BASIN SUNDAY
WILL BRING VERY STRONG WINDS TO PORTIONS OF NORTHERN ARIZONA.
BEGINNING LATE SUNDAY MORNING...SOUTHWEST WINDS WILL INCREASE TO
40 TO 50 MPH WITH GUSTS UP TO 65 MPH OVER THE LITTLE COLORADO
RIVER VALLEY AND ADJACENT AREAS. EXPECT WIND SPEEDS TO DIMINISH
SUNDAY EVENING AS THE SYSTEM MOVES EASTWARD.
PRECAUTIONARY/PREPAREDNESS ACTIONS...
A HIGH WIND WATCH MEANS THERE IS THE POTENTIAL FOR A HAZARDOUS
HIGH WIND EVENT...WITH SUSTAINED WINDS GREATER THAN 40 MPH...OR
GUSTS GREATER THAN 58 MPH. MONITOR THE LATEST FORECASTS AND
WARNINGS FOR UPDATES ON THIS SITUATION. ADDITIONAL WEATHER
INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.
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WWUS75 KFGZ 221047
NPWFGZ
URGENT - WEATHER MESSAGE
NATIONAL WEATHER SERVICE FLAGSTAFF AZ
347 AM MST SUN MAR 22 2009
AZZ010-011-016-017-039-221900-
/O.UPG.KFGZ.WI.Y.0005.090322T1600Z-090323T0600Z/
/O.NEW.KFGZ.HW.W.0001.090322T1600Z-090323T0600Z/
CHINLE VALLEY-CHUSKA MOUNTAINS AND DEFIANCE PLATEAU-
EASTERN MOGOLLON RIM-WHITE MOUNTAINS-BLACK MESA AREA-
INCLUDING THE CITIES OF...CANYON DE CHELLY...CHINLE...KAYENTA...
WINDOW ROCK...GANADO...HEBER...HAPPY JACK...FOREST LAKES...
SHOW LOW...GREER...PINETOP...NAVAJO N.M.
347 AM MST SUN MAR 22 2009
...HIGH WIND WARNING IN EFFECT FROM 9 AM THIS MORNING TO 11 PM
MST THIS EVENING...
THE NATIONAL WEATHER SERVICE IN FLAGSTAFF HAS ISSUED A HIGH WIND
WARNING...WHICH IS IN EFFECT FROM 9 AM THIS MORNING TO 11 PM MST
THIS EVENING. THE WIND ADVISORY IS NO LONGER IN EFFECT.
A STRONG LOW PRESSURE SYSTEM MOVING ACROSS THE GREAT BASIN TODAY
WILL BRING STRONG WINDS TO NORTHERN ARIZONA. SOUTHWEST WINDS WILL
BEGIN TO INCREASE BY MID MORNING...REACHING SPEEDS OF 30 TO 40 MPH
WITH GUSTS FROM 55 TO 60 MPH BY EARLY AFTERNOON. THESE STRONG
WINDS ARE ANTICIPATED TO CONTINUE INTO THE LATE EVENING HOURS AS
THE STORM SYSTEM MOVES THROUGH THE AREA.
PRECAUTIONARY/PREPAREDNESS ACTIONS...
A HIGH WIND WARNING MEANS A HAZARDOUS HIGH WIND EVENT IS EXPECTED

OR OCCURRING...WITH SUSTAINED WIND SPEEDS GREATER THAN 40 MPH OR GUSTS GREATER THAN 58 MPH. WINDS THIS STRONG CAN CAUSE PROPERTY DAMAGE. CONTINUE TO MONITOR THE LATEST FORECASTS. ADDITIONAL WEATHER INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.

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AZZ012>014-040-221900-

/O.UPG.KFGZ.HW.A.0001.090322T1600Z-090323T0600Z/

/O.NEW.KFGZ.HW.W.0001.090322T1600Z-090323T0600Z/

LITTLE COLORADO RIVER VALLEY IN COCONINO COUNTY-

LITTLE COLORADO RIVER VALLEY IN NAVAJO COUNTY-

LITTLE COLORADO RIVER VALLEY IN APACHE COUNTY-

NORTHEAST PLATEAUS AND MESAS SOUTH OF HWY 264-

INCLUDING THE CITIES OF...WUPATKI N.M....TUBA CITY...WINSLOW...

HOLBROOK...SNOWFLAKE...ST. JOHNS...SPRINGERVILLE...DILKON...

KYKOTSMOVI

347 AM MST SUN MAR 22 2009

...HIGH WIND WARNING IN EFFECT FROM 9 AM THIS MORNING TO 11 PM MST THIS EVENING...

THE NATIONAL WEATHER SERVICE IN FLAGSTAFF HAS ISSUED A HIGH WIND WARNING...WHICH IS IN EFFECT FROM 9 AM THIS MORNING TO 11 PM MST THIS EVENING. THE HIGH WIND WATCH IS NO LONGER IN EFFECT.

A STRONG LOW PRESSURE SYSTEM MOVING ACROSS THE GREAT BASIN TODAY WILL BRING VERY STRONG WINDS MUCH OF THE REGION. SOUTHWEST WINDS WILL

BEGIN TO INCREASE THIS MORNING...REACHING SPEEDS OF 35 TO 45 MPH WITH GUSTS UP TO 65 MPH OVER THE LITTLE COLORADO RIVER VALLEY AND ADJACENT AREAS BY EARLY AFTERNOON. THESE STRONG WINDS ARE

ANTICIPATED TO CONTINUE INTO THE MID TO LATE EVENING HOURS AS THE STORM SYSTEM MOVES THROUGH THE AREA. AREAS OF BLOWING DUST ARE

LIKELY AND MAY CAUSE LOCALLY REDUCED VISIBILITY ALONG AREA ROADS. PRECAUTIONARY/PREPAREDNESS ACTIONS...

A HIGH WIND WARNING MEANS A HAZARDOUS HIGH WIND EVENT IS EXPECTED OR OCCURRING...WITH SUSTAINED WIND SPEEDS GREATER THAN 40 MPH OR GUSTS GREATER THAN 58 MPH. WINDS THIS STRONG CAN CAUSE PROPERTY DAMAGE. CONTINUE TO MONITOR THE LATEST FORECASTS. ADDITIONAL WEATHER INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.

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AZZ004>009-015-018-037-038-221900-

/O.CON.KFGZ.WI.Y.0005.090322T1600Z-090323T0600Z/

KAIBAB PLATEAU-MARBLE AND GLEN CANYONS-GRAND CANYON COUNTRY-

COCONINO PLATEAU-YAVAPAI COUNTY MOUNTAINS-

NORTHEAST PLATEAUS AND MESAS HWY 264 NORTHWARD-

WESTERN MOGOLLON RIM-NORTHERN GILA COUNTY-

YAVAPAI COUNTY VALLEYS AND BASINS-OAK CREEK AND SYCAMORE CANYONS-INCLUDING THE CITIES OF...JACOB LAKE...FREDONIA...PAGE...

LEES FERRY...GRAND CANYON VILLAGE...SUPAI...NORTH RIM...VALLE...

PRESCOTT...SELIGMAN...ASH FORK...KEAMS CANYON...KAIBITO...

FLAGSTAFF...WILLIAMS...MUNDS PARK...PAYSON...STRAWBERRY...YOUNG...

COTTONWOOD...CAMP VERDE...CORDES JUNCTION...BAGDAD...SEDONA

347 AM MST SUN MAR 22 2009

...WIND ADVISORY REMAINS IN EFFECT FROM 9 AM THIS MORNING TO 11 PM MST THIS EVENING...

A WIND ADVISORY REMAINS IN EFFECT FROM 9 AM THIS MORNING TO 11 PM MST THIS EVENING.

A STRONG LOW PRESSURE SYSTEM MOVING ACROSS THE GREAT BASIN TODAY WILL BRING STRONG WINDS TO NORTHERN ARIZONA. SOUTHWEST WINDS WILL

BEGIN TO INCREASE THIS MORNING...REACHING SPEEDS OF 30 TO 40 MPH WITH GUSTS FROM 45 TO 55 MPH BY EARLY AFTERNOON. THESE STRONG WINDS ARE ANTICIPATED TO CONTINUE INTO THE LATE EVENING HOURS AS THE STORM SYSTEM MOVES THROUGH THE AREA.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

A WIND ADVISORY MEANS THAT SUSTAINED WINDS OF 30 TO 39 MPH...OR GUSTS FROM 40 TO 57 MPH...ARE EXPECTED. WINDS THIS STRONG CAN MAKE DRIVING DIFFICULT...ESPECIALLY FOR HIGH PROFILE VEHICLES. CONSIDER SECURING LOOSE BELONGINGS ON YOUR PROPERTY. ADDITIONAL WEATHER INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.

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JJ

WWUS75 KFGZ 221837

NPWFGZ

URGENT - WEATHER MESSAGE

NATIONAL WEATHER SERVICE FLAGSTAFF AZ

1137 AM MST SUN MAR 22 2009

AZZ010>014-016-017-039-040-230400-

/O.CON.KFGZ.HW.W.0001.000000T0000Z-090323T0600Z/

CHINLE VALLEY-CHUSKA MOUNTAINS AND DEFIANCE PLATEAU-

LITTLE COLORADO RIVER VALLEY IN COCONINO COUNTY-

LITTLE COLORADO RIVER VALLEY IN NAVAJO COUNTY-

LITTLE COLORADO RIVER VALLEY IN APACHE COUNTY-

EASTERN MOGOLLON RIM-WHITE MOUNTAINS-BLACK MESA AREA-

NORTHEAST PLATEAUS AND MESAS SOUTH OF HWY 264-

INCLUDING THE CITIES OF...CANYON DE CHELLY...CHINLE...KAYENTA...

WINDOW ROCK...GANADO...WUPATKI N.M....TUBA CITY...WINSLOW...

HOLBROOK...SNOWFLAKE...ST. JOHNS...SPRINGERVILLE...HEBER...

HAPPY JACK...FOREST LAKES...SHOW LOW...GREER...PINETOP...

NAVAJO N.M....DILKON...KYKOTSMOVI

1137 AM MST SUN MAR 22 2009

...HIGH WIND WARNING REMAINS IN EFFECT UNTIL 11 PM MST THIS EVENING...

A HIGH WIND WARNING REMAINS IN EFFECT UNTIL 11 PM MST THIS EVENING.

A STRONG LOW PRESSURE SYSTEM MOVING ACROSS THE GREAT BASIN TODAY WILL BRING VERY STRONG WINDS TO MUCH OF THE REGION. SOUTHWEST WINDS OF 20 TO 30 MPH HAVE DEVELOPED ACROSS LITTLE COLORADO RIVER VALLEY AND ADJACENT AREAS AND WILL CONTINUE TO INCREASE THROUGHOUT THE DAY...REACHING SPEEDS OF 35 TO 45 MPH WITH GUSTS UP TO 65 MPH BY EARLY AFTERNOON. THESE STRONG WINDS ARE ANTICIPATED TO CONTINUE INTO THE LATE EVENING HOURS AS THE STORM SYSTEM MOVES THROUGH THE REGION. AREAS OF BLOWING DUST ARE LIKELY AND MAY CAUSE LOCALLY REDUCED VISIBILITY ALONG AREA ROADS.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

A HIGH WIND WARNING MEANS A HAZARDOUS HIGH WIND EVENT IS EXPECTED OR OCCURRING...WITH SUSTAINED WIND SPEEDS GREATER THAN 40 MPH OR GUSTS GREATER THAN 58 MPH. WINDS THIS STRONG CAN CAUSE PROPERTY DAMAGE. CONTINUE TO MONITOR THE LATEST FORECASTS. ADDITIONAL WEATHER INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.

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AZZ004>009-015-018-037-038-230400-

/O.CON.KFGZ.WI.Y.0005.000000T0000Z-090323T0600Z/

KAIBAB PLATEAU-MARBLE AND GLEN CANYONS-GRAND CANYON COUNTRY-

COCONINO PLATEAU-YAVAPAI COUNTY MOUNTAINS-
 NORTHEAST PLATEAUS AND MESAS HWY 264 NORTHWARD-
 WESTERN MOGOLLON RIM-NORTHERN GILA COUNTY-
 YAVAPAI COUNTY VALLEYS AND BASINS-OAK CREEK AND SYCAMORE CANYONS-
 INCLUDING THE CITIES OF...JACOB LAKE...FREDONIA...PAGE...
 LEES FERRY...GRAND CANYON VILLAGE...SUPAI...NORTH RIM...VALLE...
 PRESCOTT...SELIGMAN...ASH FORK...KEAMS CANYON...KAIBITO...
 FLAGSTAFF...WILLIAMS...MUNDS PARK...PAYSON...STRAWBERRY...YOUNG...
 COTTONWOOD...CAMP VERDE...CORDES JUNCTION...BAGDAD...SEDONA
 1137 AM MST SUN MAR 22 2009
 ...WIND ADVISORY REMAINS IN EFFECT UNTIL 11 PM MST THIS EVENING...
 A WIND ADVISORY REMAINS IN EFFECT UNTIL 11 PM MST THIS EVENING.
 A STRONG LOW PRESSURE SYSTEM MOVING ACROSS THE GREAT BASIN TODAY
 WILL BRING STRONG WINDS TO NORTHERN ARIZONA. SOUTHWEST WINDS OF 15
 TO 25 MPH HAVE DEVELOPED ACROSS MUCH OF THE ADVISORY AREA AND WILL
 CONTINUE TO INCREASE THROUGHOUT THE DAY...REACHING SPEEDS OF 30 TO 40
 MPH WITH GUSTS FROM 45 TO 55 MPH BY EARLY AFTERNOON. THESE STRONG
 WINDS ARE ANTICIPATED TO CONTINUE INTO THE LATE EVENING HOURS AS
 THE STORM SYSTEM MOVES THROUGH THE REGION.
 THE FOLLOWING SITES HAVE VERIFIED ADVISORY CRITERIA...

GRAND CANYON AIRPORT	...	35 MPH SUSTAINED
FOUR SPRINGS RAWS	.....	43 MPH GUST
HOUSEROCK RAWS	.....	48 MPH GUST
GRAND CANYON AIRPORT	...	53 MPH GUST
FRAZIER WELLS RAWS	.....	41 MPH GUST
I-40 AT ASH FORK	.....	42 MPH GUST
HUMBUG CREEK RAWS	.....	40 MPH GUST
FLAGSTAFF AIRPORT	.....	41 MPH GUST
GREENBASE RAWS	.....	40 MPH GUST
WUPATKI RAWS	.....	42 MPH GUST
SHOW LOW AIRPORT	.....	43 MPH GUST

 PRECAUTIONARY/PREPAREDNESS ACTIONS...
 A WIND ADVISORY MEANS THAT SUSTAINED WINDS OF 30 TO 39 MPH...OR
 GUSTS FROM 40 TO 57 MPH...ARE EXPECTED. WINDS THIS STRONG CAN
 MAKE DRIVING DIFFICULT...ESPECIALLY FOR HIGH PROFILE VEHICLES.
 CONSIDER SECURING LOOSE BELONGINGS ON YOUR PROPERTY. ADDITIONAL
 WEATHER INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.
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WWUS75 KFGZ 222137
 NPWFGZ
 URGENT - WEATHER MESSAGE
 NATIONAL WEATHER SERVICE FLAGSTAFF AZ
 237 PM MST SUN MAR 22 2009
 AZZ006>009-015-230545-
 /O.UPG.KFGZ.WI.Y.0005.000000T0000Z-090323T0600Z/
 /O.EXA.KFGZ.HW.W.0001.000000T0000Z-090323T0600Z/
 GRAND CANYON COUNTRY-COCONINO PLATEAU-YAVAPAI COUNTY MOUNTAINS-
 NORTHEAST PLATEAUS AND MESAS HWY 264 NORTHWARD-
 WESTERN MOGOLLON RIM-
 INCLUDING THE CITIES OF...GRAND CANYON VILLAGE...SUPAI...
 NORTH RIM...VALLE...PRESCOTT...SELIGMAN...ASH FORK...
 KEAMS CANYON...KAIBITO...FLAGSTAFF...WILLIAMS...MUNDS PARK
 237 PM MST SUN MAR 22 2009
 ...HIGH WIND WARNING IN EFFECT UNTIL 11 PM MST THIS EVENING...
 THE NATIONAL WEATHER SERVICE IN FLAGSTAFF HAS ISSUED A HIGH WIND

WARNING...WHICH IS IN EFFECT UNTIL 11 PM MST THIS EVENING. THE WIND ADVISORY IS NO LONGER IN EFFECT.

A STRONG LOW PRESSURE SYSTEM MOVING ACROSS THE GREAT BASIN WILL BRING STRONG WINDS TO NORTHERN ARIZONA. SOUTHWEST WINDS OF 40 TO 50 MPH WITH GUSTS EXCEEDING 60 MPH HAVE DEVELOPED AND WILL CONTINUE ACROSS THE WARNING AREA. THESE STRONG WINDS ARE ANTICIPATED TO CONTINUE INTO THE LATE EVENING HOURS AS THE STORM SYSTEM MOVES THROUGH THE REGION. AREAS OF BLOWING DUST ARE LIKELY AND MAY CAUSE LOCALLY REDUCED VISIBILITY ALONG AREA ROADS. PRECAUTIONARY/PREPAREDNESS ACTIONS...

A HIGH WIND WARNING MEANS A HAZARDOUS HIGH WIND EVENT IS EXPECTED OR OCCURRING...WITH SUSTAINED WIND SPEEDS GREATER THAN 40 MPH OR GUSTS GREATER THAN 58 MPH. WINDS THIS STRONG CAN CAUSE PROPERTY DAMAGE. CONTINUE TO MONITOR THE LATEST FORECASTS. ADDITIONAL WEATHER INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.

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AZZ010>014-016-017-039-040-230545-

/O.CON.KFGZ.HW.W.0001.000000T0000Z-090323T0600Z/

CHINLE VALLEY-CHUSKA MOUNTAINS AND DEFIANCE PLATEAU-

LITTLE COLORADO RIVER VALLEY IN COCONINO COUNTY-

LITTLE COLORADO RIVER VALLEY IN NAVAJO COUNTY-

LITTLE COLORADO RIVER VALLEY IN APACHE COUNTY-

EASTERN MOGOLLON RIM-WHITE MOUNTAINS-BLACK MESA AREA-

NORTHEAST PLATEAUS AND MESAS SOUTH OF HWY 264-

INCLUDING THE CITIES OF...CANYON DE CHELLY...CHINLE...KAYENTA...

WINDOW ROCK...GANADO...WUPATKI N.M....TUBA CITY...WINSLOW...

HOLBROOK...SNOWFLAKE...ST. JOHNS...SPRINGERVILLE...HEBER...

HAPPY JACK...FOREST LAKES...SHOW LOW...GREER...PINETOP...

NAVAJO N.M....DILKON...KYKOTSMOVI

237 PM MST SUN MAR 22 2009

...HIGH WIND WARNING REMAINS IN EFFECT UNTIL 11 PM MST THIS EVENING...

A HIGH WIND WARNING REMAINS IN EFFECT UNTIL 11 PM MST THIS EVENING.

A STRONG LOW PRESSURE SYSTEM MOVING ACROSS THE GREAT BASIN TODAY WILL BRING VERY STRONG WINDS TO MUCH OF THE REGION. SOUTHWEST OF 35 TO 45 MPH WITH GUSTS UP TO 65 MPH HAVE DEVELOPED AND WILL CONTINUE ACROSS THE LITTLE COLORADO RIVER VALLEY AND ADJACENT AREAS. THESE STRONG WINDS ARE ANTICIPATED TO CONTINUE INTO THE LATE EVENING HOURS AS THE STORM SYSTEM MOVES THROUGH THE REGION. AREAS OF BLOWING DUST ARE LIKELY AND MAY CAUSE LOCALLY REDUCED VISIBILITY ALONG AREA ROADS.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

A HIGH WIND WARNING MEANS A HAZARDOUS HIGH WIND EVENT IS EXPECTED OR OCCURRING...WITH SUSTAINED WIND SPEEDS GREATER THAN 40 MPH OR GUSTS GREATER THAN 58 MPH. WINDS THIS STRONG CAN CAUSE PROPERTY DAMAGE. CONTINUE TO MONITOR THE LATEST FORECASTS. ADDITIONAL WEATHER INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.

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AZZ004-005-018-037-038-230545-

/O.CON.KFGZ.WI.Y.0005.000000T0000Z-090323T0600Z/

KAIBAB PLATEAU-MARBLE AND GLEN CANYONS-NORTHERN GILA COUNTY-

YAVAPAI COUNTY VALLEYS AND BASINS-OAK CREEK AND SYCAMORE CANYONS-

INCLUDING THE CITIES OF...JACOB LAKE...FREDONIA...PAGE...

LEES FERRY...PAYSON...STRAWBERRY...YOUNG...COTTONWOOD...

CAMP VERDE...CORDES JUNCTION...BAGDAD...SEDONA
237 PM MST SUN MAR 22 2009

...WIND ADVISORY REMAINS IN EFFECT UNTIL 11 PM MST THIS EVENING...

A WIND ADVISORY REMAINS IN EFFECT UNTIL 11 PM MST THIS EVENING.

A STRONG LOW PRESSURE SYSTEM MOVING ACROSS THE GREAT BASIN WILL
BRING STRONG WINDS TO NORTHERN ARIZONA. SOUTHWEST WINDS OF 30 TO
40 MPH WITH GUSTS FROM 45 TO 55 MPH HAVE DEVELOPED AND WILL
CONTINUE ACROSS THE ADVISORY AREA. THESE STRONG WINDS ARE
ANTICIPATED TO CONTINUE INTO THE LATE EVENING HOURS AS THE STORM
SYSTEM MOVES THROUGH THE REGION.

THE FOLLOWING SITES HAVE VERIFIED ADVISORY CRITERIA...

PRECAUTIONARY/PREPAREDNESS ACTIONS...

A WIND ADVISORY MEANS THAT SUSTAINED WINDS OF 30 TO 39 MPH...OR
GUSTS FROM 40 TO 57 MPH...ARE EXPECTED. WINDS THIS STRONG CAN
MAKE DRIVING DIFFICULT...ESPECIALLY FOR HIGH PROFILE VEHICLES.
CONSIDER SECURING LOOSE BELONGINGS ON YOUR PROPERTY. ADDITIONAL
WEATHER INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.

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AZZ011-013-014-017-040-230600-

/O.CON.KFGZ.HW.W.0001.000000T0000Z-090323T0600Z/

CHUSKA MOUNTAINS AND DEFIANCE PLATEAU-

LITTLE COLORADO RIVER VALLEY IN NAVAJO COUNTY-

LITTLE COLORADO RIVER VALLEY IN APACHE COUNTY-WHITE MOUNTAINS-

NORTHEAST PLATEAUS AND MESAS SOUTH OF HWY 264-

INCLUDING THE CITIES OF...WINDOW ROCK...GANADO...WINSLOW...

HOLBROOK...SNOWFLAKE...ST. JOHNS...SPRINGERVILLE...SHOW LOW...

GREER...PINETOP...DILKON...KYKOTSMOVI

940 PM MST SUN MAR 22 2009

...HIGH WIND WARNING REMAINS IN EFFECT UNTIL 11 PM MST THIS
EVENING...

A HIGH WIND WARNING REMAINS IN EFFECT UNTIL 11 PM MST THIS
EVENING.

A STRONG AREA OF LOW PRESSURE MOVING ACROSS UTAH THIS EVENING WILL
BRING VERY STRONG WINDS PORTIONS OF EASTERN ARIZONA. SOUTHWEST
WINDS OF 35 TO 45 MPH WITH GUSTS UP TO 65 MPH WILL CONTINUE
ACROSS THE LITTLE COLORADO RIVER VALLEY AND ADJACENT AREAS. THESE
STRONG WINDS ARE ANTICIPATED TO CONTINUE SEVERAL MORE HOURS THIS
EVENING AS THE STORM SYSTEM PROGRESSES EASTWARD ACROSS THE REST
OF THE STATE...WITH THE STRONGEST WINDS MAINLY EAST OF A WINSLOW
TO WINDOW ROCK LINE. AREAS OF BLOWING DUST ARE LIKELY AND MAY
CAUSE LOCALLY REDUCED VISIBILITY ALONG AREA ROADS.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

A HIGH WIND WARNING MEANS A HAZARDOUS HIGH WIND EVENT IS EXPECTED
OR OCCURRING...WITH SUSTAINED WIND SPEEDS GREATER THAN 40 MPH OR
GUSTS GREATER THAN 58 MPH. WINDS THIS STRONG CAN CAUSE PROPERTY
DAMAGE. CONTINUE TO MONITOR THE LATEST FORECASTS. ADDITIONAL
WEATHER INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.

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NWS SRRS PRODUCTS FOR:
2009032112 to 2009032223

Grand Junction Colorado National Weather Service Forecast Office
WWUS75 KGJT 222143

NPWGJT

URGENT - WEATHER MESSAGE

NATIONAL WEATHER SERVICE GRAND JUNCTION CO

343 PM MDT SUN MAR 22 2009

...STRONG WINDS TO CONTINUE INTO EARLY THIS EVENING...

.AN APPROACHING VIGOROUS COLD FRONT HAS RESULTED IN STRONG WINDS
ACROSS EASTERN UTAH AND WESTERN COLORADO THAT WILL CONTINUE INTO
EARLY THIS EVENING. THE WINDS ARE EXPECTED TO DECREASE SOME IN
INTENSITY TOWARDS SUNSET.

COZ001-002-005>008-011-014-020>023-UTZ022-024-027-029-230100-
/O.NEW.KGJT.WI.Y.0002.090322T2143Z-090323T0100Z/

LOWER YAMPA RIVER BASIN-CENTRAL YAMPA RIVER BASIN-

UPPER YAMPA RIVER BASIN-GRAND VALLEY-DEBEQUE TO SILT CORRIDOR-

CENTRAL COLORADO RIVER BASIN-

CENTRAL GUNNISON AND UNCOMPAHGRE RIVER BASIN-

UPPER GUNNISON RIVER VALLEY-PARADOX VALLEY/LOWER DOLORES RIVER-

FOUR CORNERS/UPPER DOLORES RIVER-ANIMAS RIVER BASIN-

SAN JUAN RIVER BASIN-SOUTHEAST UTAH-EASTERN UINTA BASIN-

ARCHES/GRAND FLAT-CANYONLANDS/NATURAL BRIDGES-

INCLUDING THE CITIES OF...RANGELY...DINOSAUR...CRAIG...HAYDEN...

MEEKER...STEAMBOAT SPRINGS AND VICINITY...GRAND JUNCTION...

FRUITA...PALISADE...RIFLE...SILT...PARACHUTE...MESA...

GLENWOOD SPRINGS...EAGLE...CARBONDALE...CEDAREDGE...DELTA...

HOTCHKISS...MONTROSE...GUNNISON...CIMARRON...GATEWAY...NUCLA...

CORTEZ...DOVE CREEK...MANCOS...DURANGO...BAYFIELD...IGNACIO...

PAGOSA SPRINGS AND VICINITY...BLANDING...BLUFF...MEXICAN HAT...

VERNAL...JENSEN...BALLARD...FORT DUCHESNE...RANDLETT...MOAB...

CASTLE VALLEY...THOMPSON SPRINGS

343 PM MDT SUN MAR 22 2009

...WIND ADVISORY IN EFFECT UNTIL 7 PM MDT THIS EVENING...

THE NATIONAL WEATHER SERVICE IN GRAND JUNCTION HAS ISSUED A WIND
ADVISORY...WHICH IS IN EFFECT UNTIL 7 PM MDT THIS EVENING.

SUSTAINED SOUTHERLY WINDS OF 20 TO 30 MPH WITH GUSTS OF 45 TO 55
MPH WILL CONTINUE INTO EARLY THIS EVENING. **BLOWING DUST IN MANY**

AREAS WILL RESULT IN REDUCED VISIBILITIES.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

**PERSONS TRAVELING ACROSS EASTERN UTAH AND WESTERN COLORADO THROUGH
EARLY THIS EVENING SHOULD BE PREPARED TO ENCOUNTER REDUCED
VISIBILITIES IN BLOWING DUST.** ADDITIONALLY...THE STRONG WINDS CAN

MAKE DRIVING DIFFICULT...ESPECIALLY FOR HIGH PROFILE VEHICLES ON
EAST-WEST ORIENTED HIGHWAYS.

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NWS SRRS PRODUCTS FOR:
2009032112 to 2009032223
Albuquerque New Mexico National Weather Service Forecast Office

WWUS75 KABQ 221103

NPWABQ

URGENT - WEATHER MESSAGE

NATIONAL WEATHER SERVICE ALBUQUERQUE NM

503 AM MDT SUN MAR 22 2009

...SHARP UPTICK IN WINDS FOR MOST OF NORTH AND CENTRAL NEW MEXICO...
.AN UPPER LEVEL TROUGH WILL SWING ACROSS THE CENTRAL ROCKIES LATER
TODAY AND TONIGHT...INCREASING WINDS ALOFT AND INCREASING THE
SURFACE PRESSURE GRADIENT...BOTH OF WHICH WILL CAUSE WINDS TO
GREATLY INCREASE OVER MUCH OF THE WESTERN THREE QUARTERS OF NEW
MEXICO TODAY AND CONTINUE INTO TONIGHT ACROSS THE WEST HALF AND
INTO MONDAY ACROSS THE EAST HALF.

NMZ008-014-221800-

/O.NEW.KABQ.WI.Y.0017.090322T1800Z-090323T0600Z/

WEST CENTRAL MOUNTAINS-SOUTHWEST MOUNTAINS/UPPER GILA REGION-

INCLUDING THE CITIES OF...GALLUP/GRANTS...GLENWOOD

503 AM MDT SUN MAR 22 2009

...WIND ADVISORY IN EFFECT FROM NOON TODAY TO MIDNIGHT MDT
TONIGHT...

THE NATIONAL WEATHER SERVICE IN ALBUQUERQUE HAS ISSUED A WIND
ADVISORY...WHICH IS IN EFFECT FROM NOON TODAY TO MIDNIGHT MDT
TONIGHT.

SOUTHWEST TO WEST WINDS WILL INCREASE RATHER QUICKLY TODAY WITH
SUSTAINED SPEEDS OF 25 TO NEARLY 40 MPH EXPECTED BY EARLY
AFTERNOON WITH OCCASIONAL GUSTS BETWEEN 45 AND 55 MPH IN SOME
LOCALES. AREAS OF BLOWING DUST ARE ALSO EXPECTED...WHICH WILL
REDUCE VISIBILITY AT TIMES. WINDS WILL GRADUALLY DIMINISH LATE
TONIGHT.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOTORISTS SHOULD EXERCISE CAUTION WHILE DRIVING IN THE WIND
ADVISORY AREA. SUDDEN GUSTS OF WIND MAY CAUSE YOU TO LOSE CONTROL
OF YOUR VEHICLE. EXTRA ATTENTION SHOULD BE GIVEN TO CROSS WINDS.

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NMZ009-015-221800-

/O.NEW.KABQ.WI.Y.0017.090322T2100Z-090323T0600Z/

MIDDLE RIO GRANDE VALLEY/ALBUQUERQUE METRO AREA-

LOWER RIO GRANDE VALLEY-

INCLUDING THE CITIES OF...ALBUQUERQUE...SOCORRO

503 AM MDT SUN MAR 22 2009

...WIND ADVISORY IN EFFECT FROM 3 PM THIS AFTERNOON TO MIDNIGHT
MDT TONIGHT...

THE NATIONAL WEATHER SERVICE IN ALBUQUERQUE HAS ISSUED A WIND
ADVISORY...WHICH IS IN EFFECT FROM 3 PM THIS AFTERNOON TO
MIDNIGHT MDT TONIGHT.

SOUTHWEST TO WEST WINDS WILL INCREASE RATHER QUICKLY THIS
AFTERNOON WITH SUSTAINED SPEEDS INCREASING TO BETWEEN 25 AND 35
MPH DURING THE AFTERNOON WITH OCCASIONAL GUSTS UP TO 40 OR 45 MPH
IN SOME LOCALES. AREAS OF BLOWING DUST MAY ALSO BE KICKED
UP...WHICH WILL REDUCE VISIBILITY AT TIMES. WINDS WILL GRADUALLY
DIMINISH LATE TONIGHT.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOTORISTS SHOULD EXERCISE CAUTION WHILE DRIVING IN THE WIND ADVISORY AREA. SUDDEN GUSTS OF WIND MAY CAUSE YOU TO LOSE CONTROL OF YOUR VEHICLE. EXTRA ATTENTION SHOULD BE GIVEN TO CROSS WINDS.

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NMZ004-005-010-011-016-017-026-221800-
/O.NEW.KABQ.WI.Y.0017.090322T2100Z-090324T0000Z/
SANGRE DE CRISTO MOUNTAINS-NORTHEAST HIGHLANDS-
SANDIA/MANZANO MOUNTAINS-CENTRAL HIGH PLAINS/ESTANCIA VALLEY-
LINCOLN COUNTY HIGH PLAINS/HONDO VALLEY-
CAPITAN/NORTHERN SACRAMENTO MOUNTAINS-
GUADALUPE MOUNTAINS OF CHAVES COUNTY-
INCLUDING THE CITIES OF...RED RIVER/TAOS/SANTA FE...
LAS VEGAS/RATON...SANDIA PARK/CEDAR CREST...MORIARTY/ESTANCIA...
CARRIZOZO...RUIDOSO

503 AM MDT SUN MAR 22 2009

...WIND ADVISORY IN EFFECT FROM 3 PM THIS AFTERNOON TO 6 PM MDT MONDAY...

THE NATIONAL WEATHER SERVICE IN ALBUQUERQUE HAS ISSUED A WIND ADVISORY...WHICH IS IN EFFECT FROM 3 PM THIS AFTERNOON TO 6 PM MDT MONDAY.

SOUTHWEST TO WEST WINDS WILL INCREASE RATHER QUICKLY THIS AFTERNOON WITH SUSTAINED SPEEDS REACHING 25 TO NEARLY 40 MPH DURING THE AFTERNOON WITH OCCASIONAL GUSTS BETWEEN 45 AND 55 MPH IN SOME LOCALES. AREAS OF BLOWING DUST MAY ALSO BE KICKED UP...WHICH WILL REDUCE VISIBILITY AT TIMES. STRONG WINDS WILL LIKELY CONTINUE TONIGHT AND THROUGH MONDAY AFTERNOON.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOTORISTS SHOULD EXERCISE CAUTION WHILE DRIVING IN THE WIND ADVISORY AREA. SUDDEN GUSTS OF WIND MAY CAUSE YOU TO LOSE CONTROL OF YOUR VEHICLE. EXTRA ATTENTION SHOULD BE GIVEN TO CROSS WINDS.

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43

WWUS75 KABQ 221743

NPWABQ

URGENT - WEATHER MESSAGE

NATIONAL WEATHER SERVICE ALBUQUERQUE NM

1143 AM MDT SUN MAR 22 2009

...SHARP UPTICK IN WINDS FOR MOST OF NORTH AND CENTRAL NEW MEXICO...

.AN UPPER LEVEL TROUGH WILL SWING ACROSS THE CENTRAL ROCKIES THROUGH TONIGHT...INCREASING WINDS ALOFT AND INCREASING THE SURFACE PRESSURE GRADIENT. THIS WILL CREATE STRONG WINDS OVER MUCH OF THE WESTERN THREE QUARTERS OF NEW MEXICO THROUGH THIS EVENING...AND CONTINUE ACROSS THE EASTERN HALF INTO MONDAY AFTERNOON.

NMZ008-014-230000-

/O.UPG.KABQ.WI.Y.0017.090322T1800Z-090323T0600Z/

/O.NEW.KABQ.HW.W.0009.090322T1800Z-090323T0600Z/

WEST CENTRAL MOUNTAINS-SOUTHWEST MOUNTAINS/UPPER GILA REGION-
INCLUDING THE CITIES OF...GALLUP/GRANTS...GLENWOOD

1143 AM MDT SUN MAR 22 2009

...HIGH WIND WARNING IN EFFECT UNTIL MIDNIGHT MDT TONIGHT...

THE NATIONAL WEATHER SERVICE IN ALBUQUERQUE HAS ISSUED A HIGH WIND WARNING...WHICH IS IN EFFECT UNTIL MIDNIGHT MDT TONIGHT. THE

WIND ADVISORY IS NO LONGER IN EFFECT.

SOUTHWEST WINDS WILL INCREASE THIS AFTERNOON TO 25 TO 35 MPH WITH GUSTS UP TO 45 MPH BY EARLY AFTERNOON. WINDS WILL INCREASE EVEN FURTHER BY LATE THIS AFTERNOON INTO EARLY THIS EVENING WITH SUSTAINED SPEEDS OF 30 TO 40 MPH WITH GUSTS UP TO 60 MPH POSSIBLE.

AREAS OF BLOWING DUST ARE ALSO EXPECTED...WHICH WILL REDUCE VISIBILITY AT TIMES. WINDS WILL GRADUALLY DIMINISH AFTER MIDNIGHT TONIGHT.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

REMEMBER...A HIGH WIND WARNING MEANS HAZARDOUS WEATHER CONDITIONS ARE IMMINENT OR HIGHLY LIKELY. VERY STRONG CROSS WINDS ARE LIKELY ALONG INTERSTATE 40...ESPECIALLY BETWEEN GALLUP AND GRANTS.

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NMZ017-230000-

/O.NEW.KABQ.HW.W.0009.090322T2100Z-090323T0600Z/

/O.EXT.KABQ.WI.Y.0017.090323T0600Z-090324T0000Z/

CAPITAN/NORTHERN SACRAMENTO MOUNTAINS-

INCLUDING THE CITY OF...RUIDOSO

1143 AM MDT SUN MAR 22 2009

...HIGH WIND WARNING IN EFFECT FROM 3 PM THIS AFTERNOON TO MIDNIGHT MDT TONIGHT...

...WIND ADVISORY NOW IN EFFECT FROM MIDNIGHT TONIGHT TO 6 PM MDT MONDAY...

THE NATIONAL WEATHER SERVICE IN ALBUQUERQUE HAS ISSUED A HIGH WIND WARNING...WHICH IS IN EFFECT FROM 3 PM THIS AFTERNOON TO MIDNIGHT MDT TONIGHT. THE WIND ADVISORY IS NOW IN EFFECT FROM MIDNIGHT TONIGHT TO 6 PM MDT MONDAY.

SOUTHWEST WILL INCREASE RATHER QUICKLY THIS AFTERNOON TO 30 TO 40 MPH WITH GUSTS UP TO 60 MPH POSSIBLE IN SOME LOCALES. WINDS WILL THEN TURN MORE WESTERLY AND DIMINISH TO 25 TO 35 MPH WITH GUSTS UP TO 45 MPH AFTER MIDNIGHT THROUGH MONDAY AFTERNOON. AREAS OF BLOWING DUST ARE ALSO POSSIBLE...WHICH WILL REDUCE VISIBILITY AT TIMES. THE STRONGEST WINDS ARE EXPECTED BETWEEN LATE THIS AFTERNOON AND MIDNIGHT.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOTORISTS SHOULD EXERCISE CAUTION WHILE DRIVING IN THE WIND ADVISORY AREA. SUDDEN GUSTS OF WIND MAY CAUSE YOU TO LOSE CONTROL OF YOUR VEHICLE. EXTRA ATTENTION SHOULD BE GIVEN TO CROSS WINDS. REMEMBER...A HIGH WIND WARNING MEANS HAZARDOUS WEATHER CONDITIONS ARE IMMINENT OR HIGHLY LIKELY.

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NMZ001-230000-

/O.EXB.KABQ.WI.Y.0017.090322T1800Z-090323T0600Z/

NORTHWEST PLATEAU-

INCLUDING THE CITY OF...FARMINGTON

1143 AM MDT SUN MAR 22 2009

...WIND ADVISORY IN EFFECT UNTIL MIDNIGHT MDT TONIGHT...

THE NATIONAL WEATHER SERVICE IN ALBUQUERQUE HAS ISSUED A WIND ADVISORY...WHICH IS IN EFFECT UNTIL MIDNIGHT MDT TONIGHT.

SOUTHWEST WINDS WILL INCREASE RATHER QUICKLY THIS AFTERNOON TO 25 TO 35 MPH WITH GUSTS UP TO 45 MPH IN SOME LOCALES. THE STRONGEST WINDS ARE EXPECTED ALONG THE HIGHWAY 491 CORRIDOR BETWEEN NASCHITTI AND SHIPROCK. AREAS OF BLOWING DUST ARE ALSO POSSIBLE...WHICH WILL REDUCE VISIBILITY AT TIMES. WINDS WILL GRADUALLY DIMINISH LATE TONIGHT. PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOTORISTS SHOULD EXERCISE CAUTION WHILE DRIVING IN THE WIND ADVISORY AREA. SUDDEN GUSTS OF WIND MAY CAUSE YOU TO LOSE CONTROL OF YOUR VEHICLE. EXTRA ATTENTION SHOULD BE GIVEN TO CROSS WINDS.

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NMZ009-015-230000-

/O.CON.KABQ.WI.Y.0017.090322T2100Z-090323T0600Z/

MIDDLE RIO GRANDE VALLEY/ALBUQUERQUE METRO AREA-

LOWER RIO GRANDE VALLEY-

INCLUDING THE CITIES OF...ALBUQUERQUE...SOCORRO

1143 AM MDT SUN MAR 22 2009

...WIND ADVISORY REMAINS IN EFFECT FROM 3 PM THIS AFTERNOON TO MIDNIGHT MDT TONIGHT...

A WIND ADVISORY REMAINS IN EFFECT FROM 3 PM THIS AFTERNOON TO MIDNIGHT MDT TONIGHT.

SOUTHWEST WINDS WILL INCREASE RATHER QUICKLY THIS AFTERNOON TO 25 TO 35 MPH WITH GUSTS UP TO 45 MPH IN SOME LOCALES. AREAS OF BLOWING DUST ARE ALSO POSSIBLE...WHICH WILL REDUCE VISIBILITY AT TIMES. WINDS WILL GRADUALLY DIMINISH LATE TONIGHT.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOTORISTS SHOULD EXERCISE CAUTION WHILE DRIVING IN THE WIND ADVISORY AREA. SUDDEN GUSTS OF WIND MAY CAUSE YOU TO LOSE CONTROL OF YOUR VEHICLE. EXTRA ATTENTION SHOULD BE GIVEN TO CROSS WINDS.

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NMZ004-005-010-011-016-026-230000-

/O.CON.KABQ.WI.Y.0017.090322T2100Z-090324T0000Z/

SANGRE DE CRISTO MOUNTAINS-NORTHEAST HIGHLANDS-

SANDIA/MANZANO MOUNTAINS-CENTRAL HIGH PLAINS/ESTANCIA VALLEY-

LINCOLN COUNTY HIGH PLAINS/HONDO VALLEY-

GUADALUPE MOUNTAINS OF CHAVES COUNTY-

INCLUDING THE CITIES OF...RED RIVER/TAOS/SANTA FE...

LAS VEGAS/RATON...SANDIA PARK/CEDAR CREST...MORIARTY/ESTANCIA... CARRIZOZO

1143 AM MDT SUN MAR 22 2009

...WIND ADVISORY REMAINS IN EFFECT FROM 3 PM THIS AFTERNOON TO 6 PM MDT MONDAY...

A WIND ADVISORY REMAINS IN EFFECT FROM 3 PM THIS AFTERNOON TO 6 PM MDT MONDAY.

SOUTHWEST TO WEST WINDS WILL CONTINUE INCREASING THIS AFTERNOON WITH SUSTAINED SPEEDS OF 25 TO NEARLY 40 MPH WITH OCCASIONAL GUSTS BETWEEN 45 AND 55 MPH IN SOME LOCALES. AREAS OF BLOWING DUST ARE ALSO POSSIBLE... WHICH WILL REDUCE VISIBILITY AT TIMES. STRONG WINDS WILL LIKELY CONTINUE TONIGHT AND THROUGH MONDAY AFTERNOON. PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOTORISTS SHOULD EXERCISE CAUTION WHILE DRIVING IN THE WIND ADVISORY AREA. SUDDEN GUSTS OF WIND MAY CAUSE YOU TO LOSE CONTROL OF YOUR VEHICLE. EXTRA ATTENTION SHOULD BE GIVEN TO CROSS WINDS.

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WWUS75 KABQ 222353

NPWABQ

URGENT - WEATHER MESSAGE

NATIONAL WEATHER SERVICE ALBUQUERQUE NM

553 PM MDT SUN MAR 22 2009

...STRONG WINDS CONTINUE ACROSS PORTIONS OF NEW MEXICO...

.AN UPPER LEVEL TROUGH WILL SWING ACROSS THE CENTRAL ROCKIES TONIGHT...INCREASING WINDS ALOFT AS WELL AS INCREASING THE SURFACE PRESSURE GRADIENT. THIS WILL CREATE STRONG WINDS OVER MUCH OF CENTRAL AND WESTERN NEW MEXICO THROUGH AT LEAST MIDNIGHT. THE STRONGEST WINDS WILL THEN SHIFT TO AREAS ALONG AND EAST OF THE CENTRAL MOUNTAIN CHAIN ON MONDAY.

NMZ017-230600-

/O.CON.KABQ.HW.W.0009.000000T0000Z-090323T0600Z/

/O.CON.KABQ.WI.Y.0017.090323T0600Z-090324T0000Z/

CAPITAN/NORTHERN SACRAMENTO MOUNTAINS-

INCLUDING THE CITY OF...RUIDOSO

553 PM MDT SUN MAR 22 2009

...HIGH WIND WARNING REMAINS IN EFFECT UNTIL MIDNIGHT MDT TONIGHT...

...WIND ADVISORY REMAINS IN EFFECT FROM MIDNIGHT TONIGHT TO 6 PM MDT MONDAY...

A HIGH WIND WARNING REMAINS IN EFFECT UNTIL MIDNIGHT MDT TONIGHT.

A WIND ADVISORY REMAINS IN EFFECT FROM MIDNIGHT TONIGHT TO 6 PM MDT MONDAY.

SOUTHWEST WINDS OF 30 TO 40 MPH WITH GUSTS UP TO 60 MPH WILL CONTINUE THROUGH THE EVENING HOURS ACROSS THE NORTHERN SACRAMENTO MOUNTAINS. WINDS WILL BECOME MORE WESTERLY AND DIMINISH TO 25 TO 35 MPH WITH GUSTS UP TO 45 MPH AFTER MIDNIGHT THROUGH MONDAY AFTERNOON. AREAS OF BLOWING DUST ARE ALSO POSSIBLE...WHICH WILL REDUCE VISIBILITY AT TIMES. THE STRONGEST WINDS ARE EXPECTED THROUGH MIDNIGHT.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

REMEMBER...A HIGH WIND WARNING MEANS HAZARDOUS WEATHER CONDITIONS ARE IMMINENT OR HIGHLY LIKELY.

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NMZ008-014-230600-

/O.CON.KABQ.HW.W.0009.000000T0000Z-090323T0600Z/

WEST CENTRAL MOUNTAINS-SOUTHWEST MOUNTAINS/UPPER GILA REGION-

INCLUDING THE CITIES OF...GALLUP/GRANTS...GLENWOOD

553 PM MDT SUN MAR 22 2009

...HIGH WIND WARNING REMAINS IN EFFECT UNTIL MIDNIGHT MDT TONIGHT...

A HIGH WIND WARNING REMAINS IN EFFECT UNTIL MIDNIGHT MDT TONIGHT.

SOUTHWEST WINDS OF 35 TO 45 MPH WITH GUSTS UP TO 60 MPH WILL CONTINUE ACROSS THE WEST CENTRAL AND SOUTHWEST MOUNTAINS THROUGH MIDNIGHT. AREAS OF BLOWING DUST ARE ALSO EXPECTED...WHICH WILL REDUCE VISIBILITY AT TIMES. WINDS WILL GRADUALLY DIMINISH AFTER MIDNIGHT TONIGHT.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

REMEMBER...A HIGH WIND WARNING MEANS HAZARDOUS WEATHER CONDITIONS ARE IMMINENT OR HIGHLY LIKELY. VERY STRONG CROSS WINDS ARE LIKELY ALONG INTERSTATE 40...ESPECIALLY BETWEEN GALLUP AND GRANTS.

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NMZ009-015-230600-

/O.CON.KABQ.WI.Y.0017.000000T0000Z-090323T0600Z/

MIDDLE RIO GRANDE VALLEY/ALBUQUERQUE METRO AREA-

LOWER RIO GRANDE VALLEY-

INCLUDING THE CITIES OF...ALBUQUERQUE...SOCORRO

553 PM MDT SUN MAR 22 2009

...WIND ADVISORY REMAINS IN EFFECT UNTIL MIDNIGHT MDT TONIGHT...

A WIND ADVISORY REMAINS IN EFFECT UNTIL MIDNIGHT MDT TONIGHT.
SOUTHWEST WINDS OF 25 TO 35 MPH WITH GUSTS UP TO 45 MPH WILL
CONTINUE ACROSS THE MIDDLE AND LOWER RIO GRANDE VALLEY THROUGH THE
EVENING HOURS. AREAS OF BLOWING DUST ARE ALSO POSSIBLE...WHICH WILL
REDUCE VISIBILITY AT TIMES. WINDS WILL GRADUALLY DIMINISH LATE
TONIGHT.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOTORISTS SHOULD EXERCISE CAUTION WHILE DRIVING IN THE WIND
ADVISORY AREA. SUDDEN GUSTS OF WIND MAY CAUSE YOU TO LOSE CONTROL
OF YOUR VEHICLE. EXTRA ATTENTION SHOULD BE GIVEN TO CROSS WINDS.

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NMZ004-005-010-011-016-026-230600-

/O.CON.KABQ.WI.Y.0017.000000T0000Z-090324T0000Z/

SANGRE DE CRISTO MOUNTAINS-NORTHEAST HIGHLANDS-

SANDIA/MANZANO MOUNTAINS-CENTRAL HIGH PLAINS/ESTANCIA VALLEY-

LINCOLN COUNTY HIGH PLAINS/HONDO VALLEY-

GUADALUPE MOUNTAINS OF CHAVES COUNTY-

INCLUDING THE CITIES OF...RED RIVER/TAOS/SANTA FE...

LAS VEGAS/RATON...SANDIA PARK/CEDAR CREST...MORIARTY/ESTANCIA...

CARRIZOZO

553 PM MDT SUN MAR 22 2009

...WIND ADVISORY REMAINS IN EFFECT UNTIL 6 PM MDT MONDAY...

A WIND ADVISORY REMAINS IN EFFECT UNTIL 6 PM MDT MONDAY.

SOUTHWEST TO WEST WINDS WILL CONTINUE TONIGHT THROUGH MONDAY WITH
SUSTAINED SPEEDS OF 25 TO 35 MPH WITH OCCASIONAL GUSTS BETWEEN 45
AND 55 MPH. AREAS OF BLOWING DUST ARE ALSO POSSIBLE... WHICH WILL
REDUCE VISIBILITY AT TIMES.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOTORISTS SHOULD EXERCISE CAUTION WHILE DRIVING IN THE WIND
ADVISORY AREA. SUDDEN GUSTS OF WIND MAY CAUSE YOU TO LOSE CONTROL
OF YOUR VEHICLE. EXTRA ATTENTION SHOULD BE GIVEN TO CROSS WINDS.

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NMZ001-230600-

/O.CON.KABQ.WI.Y.0017.000000T0000Z-090323T0600Z/

NORTHWEST PLATEAU-

INCLUDING THE CITY OF...FARMINGTON

553 PM MDT SUN MAR 22 2009

...WIND ADVISORY REMAINS IN EFFECT UNTIL MIDNIGHT MDT TONIGHT...

A WIND ADVISORY REMAINS IN EFFECT UNTIL MIDNIGHT MDT TONIGHT.

SOUTHWEST WINDS OF 25 TO 35 MPH WITH GUSTS UP TO 45 MPH WILL
CONTINUE ACROSS THE NORTHWEST PLATEAU. THE STRONGEST WINDS ARE
EXPECTED ALONG THE HIGHWAY 491 CORRIDOR BETWEEN NASCHITTI AND
SHIPROCK. AREAS OF BLOWING DUST ARE ALSO POSSIBLE...WHICH WILL
REDUCE VISIBILITY AT TIMES. WINDS WILL GRADUALLY DIMINISH LATE
TONIGHT.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOTORISTS SHOULD EXERCISE CAUTION WHILE DRIVING IN THE WIND
ADVISORY AREA. SUDDEN GUSTS OF WIND MAY CAUSE YOU TO LOSE CONTROL
OF YOUR VEHICLE. EXTRA ATTENTION SHOULD BE GIVEN TO CROSS WINDS.

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